



AD NO. \_\_\_\_\_  
REPORT NO. ATC-8487



FINAL REPORT  
FOR THE  
ALTERNATIVE CLEANER MATERIALS COMPATIBILITY  
EVALUATION PROGRAM

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JUNE 2002

Period covered:  
May 1999 through January 2002

Prepared for:  
U.S. Army Environmental Center  
ATTN: SFIM-AE-P2&ETD

U.S. ARMY ENVIRONMENTAL CENTER  
ABERDEEN PROVING GROUND, MD 21010-5401

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REPORT DOCUMENTATION PAGE					Form Approved OMB No. 0704-0188	
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1. REPORT DATE (DD-MM-YYYY) June 2002		2. REPORT TYPE Final			3. DATES COVERED (From - To) May 1999 through January 2002	
4. TITLE AND SUBTITLE <b>FINAL REPORT FOR THE ALTERNATIVE CLEANER MATERIALS COMPATIBILITY EVALUATION PROGRAM, TEST PROTOCOL</b>				5a. CONTRACT NUMBER		
				5b. GRANT NUMBER		
				5c. PROGRAM ELEMENT NUMBER		
6. AUTHOR(S) Taylor, William H.; Ziegler, Wayne; Newton, William				5d. PROJECT NUMBER 1-CO-210-000-070		
				5e. TASK NUMBER		
				5f. WORK UNIT NUMBER		
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Commander U.S. Army Aberdeen Test Center ATTN: CSTE-DTC-AT-SL-F Aberdeen Proving Ground, MD 21005-5059					8. PERFORMING ORGANIZATION REPORT NUMBER ATC-8487	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Commander U.S. Army Environmental Center ATTN: SFIM-AE-P2&ETD Aberdeen Proving Ground, MD 21010-5401					10. SPONSOR/MONITOR'S ACRONYM(S) USAEC	
					11. SPONSOR/MONITOR'S REPORT NUMBER(S) SFIM-AEC-ET-TR-99062	
12. DISTRIBUTION/AVAILABILITY STATEMENT Distribution Unlimited						
13. SUPPLEMENTARY NOTES Prepared in cooperation with AMCOM, TACOM, ARDEC, CHPPM, AAPPSO, et.al.						
14. ABSTRACT Many federal, state and local laws and regulations limit the use, storage and disposal of hydrocarbon-based cleaning solutions. Unfortunately, the Army and other defense agencies rely on these solvents to maintain unique, mission-critical systems and materiel. The uncontrolled replacement of these solvents with environmentally friendly products has the potential to reduce the readiness of Army's legacy systems. Thus, testing has become a critical component in the process to gain approval to use alternative cleaners in DoD maintenance and repair activities. The preponderance of test methods established in this protocol are in accordance with recognized national and international test methods endorsed by the American Society for Testing and Materials (ASTM) and the Society of Automotive Engineers (SAE). Military unique test specifications and standards are identified where necessary to meet mission-oriented criteria. The intent of this protocol was to determine which materials and what tests were needed to develop data to determine the material compatibility of alternative cleaners. Final approval of the form, content of this document and resultant required data rest with the commodity commands who have the ultimate approval authority for determining criteria and approving the use of alternative cleaners on material items under their purview.						
15. SUBJECT TERMS Aqueous solvent, solvent substitution, performance validation, material compatibility, cleaner evaluation, alternative solvent reliability.						
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT  SAR	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON William H. Taylor Jr.	
a. REPORT Unclassified	b. ABSTRACT Unclassified	c. THIS PAGE Unclassified			19b. TELEPHONE NUMBER (include area code) 410-278-4098/ whtaylor@atc.army.mil	

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## FOREWORD

The U.S. Army Environmental Center (AEC) and the U.S. Aberdeen Test Center (ATC) would like to acknowledge the contributions by the following commands. Without their assistance in the identification of materials and test methods, and commitment to the reduction of solvent use, this report would not have been possible.

The U.S. Army Tank-automotive and Armaments Command (TACOM); U.S. Army Tank-Automotive Research, Development and Engineering Center (TARDEC).

The U.S. Army Aviation and Missile Command (AMCOM); The U.S. Army Aviation and Missile Research Development and Engineering Center (ARMDEC).

The U.S. Army Tank-automotive and Armaments Command (TACOM); U.S. Army Armament Research, Development and Engineering Center (ARDEC).

## EXECUTIVE DIGEST

### 1.1 INTRODUCTION

The U.S. Army Environmental Center (AEC) and the U.S. Army Aberdeen Test Center have (ATC) established the Alternative Cleaner Evaluation Program to facilitate test and evaluation of alternative cleaners proposed as substitutes for hazardous, toxic, and flammable solvents.

Federal, state, and local regulations have strict requirements for hydrocarbon-based cleaning solvents that limit their use, storage, and disposal. Hydrocarbon-based solvents are often toxic, flammable, contain hazardous air pollutants and high volatile organic compounds (VOCs), and/or other hazards to the environment. Currently, many of the cleaning agents used by the Army are hydrocarbon-based. In order to comply with pollution prevention mandates, installation environmental staffs have advocated the use of alternative cleaners to replace P-D-680 solvents. In many cases this would result in the application of a cleaner upon a tactical system without approval from the commodity command responsible for the tactical system. In certain instances, the material compatibility and effectiveness of these alternative cleaners has a potential impact on system readiness. The current means of operating and maintaining the current tactical systems is very effective.

The environmental issues associated with solvents are realized at the installation level and do not directly affect the commodity command. There is little incentive for the commodity commands to accept the increase risk to the weapon system by altering current cleaning practices to a more environmentally friendly alternative. Unfortunately the potential impact of alternative cleaners on weapon systems is not widely understood at the installations and uncontrolled product substitution has occurred. This leaves the soldier in the maintenance shop in a conundrum - use the solvents specified in the Technical Manuals or use the alternative cleaners provided by the installation.

An Army Alternative Cleaners Program has been developed with the intent to provide material compatibility data to enable commodity command decision makers to evaluate alternative cleaners for application on their specific weapon systems. A broad approach to implementing alternative cleaners substitution is being taken. Needs were solicited from the various commodity command POCs to determine what material compatibility information would be required to satisfy their decision-making process. From these interactions this Alternative Cleaners Material Compatibility Protocol was developed.

### 1.2 BACKGROUND

a. The use of solvents in general maintenance, cleaning, and repair operations has been under scrutiny during the last few decades. This evolved from the concern of the long-term effects of solvent use on worker health and safety and the environment. This led to promulgation of policies, laws, and regulations that effect the solvent's procurement, storage, use and disposal. Therefore, many federal, state, and local laws and regulations limit the use, storage, and disposal

of hydrocarbon-based cleaning solvents due to their classification as hazardous, flammable, or toxic substances. Unfortunately, the Army and other defense agencies rely on these solvents to maintain unique mission-critical systems and materiel.

b. The transition from the exclusive use of solvents to more environmentally friendly alternatives is a relatively recent phenomenon. Alternative cleaners have the potential to decrease solvent use, which will ultimately lead to improved environmental stewardship. Unfortunately, an environmental friendly designation is not associated with a product's ability to perform a particular task (e.g., cleaning, stripping, and polishing), or whether it is compatible with the materials being cleaned, polished, or stripped.

### 1.3 PURPOSE

The purpose of the Alternative Cleaner Evaluation Program is to provide a mechanism to evaluate alternative cleaner applicability in U.S. Army/Department of Defense (DOD) maintenance, cleaning, and repair activities. The purpose of this protocol is to provide procedures to develop independent test data with regards to the material compatibility of alternate cleaners.

Associated Alternative Cleaner Evaluation Program goals include:

- a. Quantifying and qualifying both the commodity managers and user needs.
- b. Developing and maintaining protocols for test and evaluation of alternative cleaners.
- c. Conducting and providing defensible data through test and evaluation.
- d. Documenting results and lessons learned.
- e. Facilitating the development and use of a decision tool.

### 1.4 PROBLEM DESCRIPTION

a. The current procurement system causes a problem when selecting and using alternative cleaners. Even though a product is listed in DLA catalogs as "environmentally friendly" or has a GSA contract number, there is no guarantee that the product has been verified or is authorized for military use. This has led purchasing organizations to procure these products without realizing or understanding the potential impacts to soldiers that use them, the materiel items they are used on and ultimately, readiness.

b. Many purchasing organizations are unaware of the approval process or the validation needed before making any changes to established maintenance procedures or cleaning regimens. As a result, the uncontrolled replacement of solvents with potentially environmentally friendly products has resulted in a number of use, approval, and material compatibility problems. Problems such as these have driven the need to better understand materials compatibility requirements, establish validation standards, prevent duplication of effort, and facilitate expeditious review and approval of alternative cleaner use where deemed appropriate.

## 1.5 PROGRAM APPROACH

The compatibility of alternative cleaners, proposed as substitutes for solvents currently used on tactical systems, must be determined to ensure the substitution does not reduce the effectiveness of the system. Within the Army, the authority to approve changes to the maintenance of weapon systems resides with the associated Program Manager. The Program Manager typically solicits evaluation input from the corresponding commodity Research Development and Engineering Center prior to approving the use of alternative cleaners on the equipment they control. The Alternative Cleaner Evaluation Program establishes a mechanism to achieve this objective. This Alternative Cleaner Materials Compatibility Protocol provides procedures to develop independent test data with regard to the material compatibility of alternate cleaners. This is the first step in the Alternative Cleaner Evaluation Program. Unfortunately, answering the materials compatibility issue alone does not provide the Army commodity commands enough information to make a substitution decision due to questions regarding alternative cleaner performance and logistics. Answers to these questions also have a potential impact on readiness. Without answering these questions, supplying material compatibility data to the commodity commands may not lead to approval for use on tactical systems. It is believed that evaluating alternative cleaners is going to receive little attention from the Weapon System Program Managers because of the increased risk to their program and a lack of a return on investment of their material development dollars.

### 1.5.1 Commodity Manger Coordination and Protocol Development

a. Building on past experience and lessons learned, the Army has launched the Alternative Cleaner Evaluation Program. This will allow manufacturers to have the compatibility and performance of alternative cleaners tested to established, repeatable methods and criteria, using appropriate system materials. Using a materials compatibility protocol developed recently in partnership with commodity managers, AEC and ATC are leading this multi-agency initiative to comprehensively test multiple products and gather data the Army and other DOD services can use to make decisions as to what cleaners should proceed to performance testing.

b. The materials compatibility protocol was developed with the help and at the direction of Commodity Command Approval Authorities (CCAA). It should be noted that the protocol requirements and test methods might change at anytime as directed by the CCAA or ATC. However, if any changes are made to the protocol before, during, or after testing notice of those changes shall be given.

c. The intent of the Alternative Cleaner Materials Compatibility Evaluation Program is to evaluate potential cleaners to satisfy both mission material compatibility and environmental needs. These needs include that the alternative cleaner be environmentally beneficial compared to current methods and not degrade the readiness of current weapon systems. Cleaners to be tested must be commercially mature and ready for implementation. Testing will be divided into phases allowing both the vendor and the U. S. Army to evaluate the product's potential early within the process.



### 1.5.2 ATC Alternative Cleaner Materials Compatibility Test Process

a. ATC will conduct compatibility evaluation and may allow technology providers to observe on designated occasions. Test parameters within the protocol focus on worker safety, constituent evaluation, material compatibility, and environmental quality benefits reflective of the alternative cleaner. Participants will be able to review ongoing testing results of their products on-line, through a web-based, password protected program. The results of compatibility and performance evaluation testing will be published in a final report that will be prepared by ATC for private industry participant use and for the commodity manager approval process. Final reports provided to private industry participants will be a sanitized version containing the industry participant's data and results only. The version of the final report provided to the commodity managers will be used to identify solvent substitutes that meet their stringent military maintenance, service, and repair requirements. All data generated will be the property of both the participant and the government.

b. Private industry participants will be required to fund all direct costs of the testing. Under the terms of the program, private industry participants will be required to pay for compatibility testing of their specific products while government funds will be used to establish and maintain the test capability, to evaluate manufacturer/vendor furnished data, and to administer the program. The private industry funding required for the testing will be determined by the cost to manage, perform, and report upon each of the protocol tests.

c. The technology provider is expected to be able to contribute materials and funds for testing. Specifically, the technology provider must plan to cover the costs and/or labor for the following:

- (1) Attending a "vendor's kick-off meeting" at the test location.
- (2) Program and testing materials.
- (3) Sending cleaner, and if necessary, equipment to support the cleaner, to ATC as required for testing.
- (4) Assisting with set-up and training of the equipment (if necessary) for testing.

### 1.5.3 Test Participation Agreement

a. Government testing can be conducted by ATC pursuant to a Test Support Agreement executed by ATC with each participating private party. Testing will be executed by ATC staff at ATC's facilities unless ATC does not have the existing capabilities to do so. In this case, another laboratory having the desired expertise will be used. ATC is responsible for:

- (1) Consolidation and forwarding of third party data to commodity commands for evaluation.
- (2) Conducting the evaluation testing.

(3) Preparing a draft evaluation report for review and comment by commodity approval authorities and private industry participants.

(4) Preparing and disseminating the final report and any other related information.

b. The test and evaluation process is considered complete when the final report has been provided to commodity approval authorities.

#### 1.5.4 Participant Coordination Meetings

Meetings with potential private industry participants will ensure understanding of program objectives, private industry roles and the test and evaluation scope, including: environmental evaluation factors, quality evaluation factors required for approval, user implementation decisions, data valuable to technology providers to promote products, and data valuable to end users of the product. For evaluation testing, AEC and ATC will include private industry participants whose products meet the defined requirements and who are willing to provide the funding determined after all responses have been received.

#### 1.5.5 Proprietary Information

Proprietary information may be required to be released for government consumption only as necessary to evaluate constituents or to determine a cleaner's potential impact on the environment, safety, and occupational health. It is recommended that this type of information be kept to a minimum.

### 1.6 LIMITATIONS

It is unlikely that an alternative cleaner drop in replacement will be found for hydrocarbon solvents currently used in U.S. Army/DOD maintenance, cleaning, and repair activities. Although manufactures and vendors will realize substantial benefits through participating in the Alternative Cleaner Materials Compatibility Evaluation Program, they may still have to be actively involved in optimizing potential solutions to meet specific user needs and requirements. Additional requirements may include tasks such as performing on site demonstrations, training installation staff, or reconfiguring and refining equipment and processes to fit site specific needs.

### 1.7 CONCLUSIONS

a. The most striking benefit derived from the Alternative Cleaner Materials Compatibility Evaluation Program has been the development of the program's test protocol. The development, endorsement, and use of a uniform protocol by the various Army commodity commands prevents the need to test products several times under differing methods and criteria and thus reduces the possibility for duplication of effort. This benefit reduces the needless expenditure of time, resources, and manpower that could otherwise be used for acquisition, infrastructure, or training.

b. A better understanding of user needs and disseminating knowledge of the approval process throughout the Department of the Army is a critical component and major benefit of the Alternative Cleaner Materials Compatibility Evaluation Program. To realize ultimate success, it is vitally important that purchasing organizations and field activities be made aware of the detrimental effects the use of unproven and unauthorized solvent substitutes can have on their mission, material, and readiness.

c. Most of all, the Army will be able to better preserve readiness, save money, and avoid bad decisions by knowing which alternative cleaning products meet its stringent requirements for materials compatibility, soldier safety, and environmental compliance. Participation will help vendors and manufacturers maximize marketing resources and will alleviate the need to do product-specific evaluations at the direction of each potential user or customer, thus saving significant time, money, and resources. In addition, if formally adopted by the Army Acquisition community, vendors and manufacturers will have an accepted process for validating their products for possible, not guaranteed, defense procurement.

## 1.8 POINTS OF CONTACT

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## **SECTION 1. MATERIAL COMPATIBILITY**

<b>Alternative Cleaner Test Protocol Material Compatibility</b>	
<b>1.1 Corrosion</b>	
<b>Test</b>	<b>Method</b>
1.1.1 Total Immersion Corrosion	ASTM F-483-98
1.1.2 Hot Dip Galvanizing Corrosion	ASTM F-483-98
1.1.3 Low Embrittling Cadmium Plate Corrosion	ASTM F-1111-88 (1998)
1.1.4 Elevated Temperature Corrosion/Stock Loss	SAE ARP 1755-00
1.1.5 Sandwich Corrosion	ASTM F-1110-90 (1998)
1.1.6 Hydrogen Embrittlement	ASTM F-519-97
1.1.7 Effects on Unpainted Surfaces	ASTM F-485-98
1.1.8 Stress Corrosion	ASTM G-44-99 (Modified per ASTM D-6361-98 App X2)
1.1.9 Copper Corrosion	ASTM D-130-94 (2000)
1.1.10 Steel Corrosion	ASTM D-130-94 (2000)
1.1.11 Bimetal Corrosion	FED STD-791C, Test Method 5322.2
<b>1.2 Effects on Surfaces</b>	
<b>Test</b>	<b>Method</b>
1.2.1 Effects on Painted Surfaces	ASTM F-502-93(1998)

ASTM = American Society for Testing and Materials.

## SECTION 1 (CONT'D)

1.3 Plastics/Sealants	
Test	Method
1.3.1 Effects on Coated Wire and Heat Shrink Tubing	ASTM D-6361 App X1
1.3.2 Effects on Acrylic Plastics	ASTM F-484-83 (1998)
1.3.3 Effects on Polycarbonate Plastic	ASTM F-484-83 (1998)
1.3.4 Effects on Polysulfide Sealants	ASTM D-6361 App X3
1.3.5.1 Rubber Compatibility - Durometer Hardness	ASTM D-2240-95, D-395, D-471
1.3.5.2 Rubber Compatibility - Compression Set	ASTM D-2240-95, D-395
1.3.5.3 Rubber Compatibility - Mass, Volume and Dimension Change	ASTM D-471
1.3.5.4 Rubber Compatibility - Mechanical Properties	ASTM D-471, D-412
1.3.6.1 Effects on Polychlorotrifluoroethylene (PCTFE), Tensile Strength and Elongation	ASTM D-638
1.3.6.2 Effects on PCTFE, Impact Strength	ASTM D256
1.3.6.3 Effects on PCTFE, Specific Gravity	ASTM D-792-98
1.3.6.4 Effects on PCTFE, Dimensional Stability	ASTM D-792-98
1.3.7 Effects on Single Component Sealing, Locking, and Retaining Compounds	MIL-S-22473E

## 1.1 CORROSION

### 1.1.1 Total Immersion Corrosion

#### Objective

The objective of this test is to determine the total immersion characteristics of the manufacturer's suggested working concentration of the cleaning compound.

#### Criterion

The manufacturer's suggested working concentration of the cleaning compound shall not show any indication of staining, etching, pitting, or localized attack on the test panels, or cause weight change to an average of three (3) test panels greater than that shown in Table 1.1-1 (Test Protocol). After salt fog testing, the corrosion on the test panels shall not be worse than the panels immersed in the PD680 solvent.

TABLE 1.1-1. ALLOY AND MAXIMUM  
AVERAGE WEIGHT LOSS

Alloy	Weight Loss, mg/cm <sup>2</sup> /168 hr
PH 13-8 Mo	0.49
C-250	.49
Magnesium (AZ31B-H24) <sup>a</sup>	.70
Aluminum 7075-T6	.49
Titanium 6AL-4V	.35
Steel 4340	.49
Steel 4340 Zinc- Phosphate Coated	b <sub>-</sub>
Steel 4340 Manganese- Phosphate Coated	b <sub>-</sub>
Copper Alloy (Brass) UNS C36000	b <sub>-</sub>
Copper Alloy UNS C10100 HO2 HH	b <sub>-</sub>
Silver Plated Steel MIL STD-171E, para 5.1	b <sub>-</sub>
Aluminum 2024-T3	.49
Aluminum 5052-H32	.49
Aluminum 6061-T6	.49

<sup>a</sup>AMS 4377 (app B, ref 1.1-1) surface treated in accordance with AMS-M-3171, Type III (app B, ref 1.1-2).

<sup>b</sup>No criteria specified.

## Test Procedures

The total immersion corrosion caused by the manufacturer's suggested working concentration of the cleaning compound is determined using ASTM F-483-98 (app B, 1.1-3), Standard Test Method for Total Immersion Corrosion Test for Aircraft Maintenance Chemicals.

a. Four test specimens, 50.8 by 25.4 by 1.6 mm (2 by 1 by 0.06 in.) with a 3.2-mm (0.125 in.) diameter mounting hole suitably located at one end of the specimen, are prepared from the same sheet stock of each of the following materials:

- (1) PH 13-8 Mo (high-strength steel).
- (2) Maraging C-250 (high-strength steel).
- (3) Aluminum 7075-T6 (non-clad).
- (4) Titanium 6AL-4V.
- (5) Steel 4340.
- (6) Magnesium (AZ31B-H24)<sup>1</sup>.
- (7) Copper alloy (brass) UNS C36000.
- (8) Copper alloy UNS C10100 HO2 (half hard).
- (9) Silver plated steel (MIL-STD-171E, para 5.1).
- (10) Aluminum 2024-T3 (non-clad).
- (11) Aluminum 5052-H32 (non-clad).
- (12) Aluminum 6061-T6 (non-clad).
- (13) Aluminum 7075-T6 (non-clad).

b. Twelve test specimens, 50.8 by 25.4 by 1.6 mm (2 by 1 by 0.06 in.) with a 3.2 mm (0.125 in.) diameter mounting hole suitably located at one end of the specimen, are prepared from the same sheet stock of each of the following materials:

- (1) Steel 4340 with zinc-phosphated coating MIL-DTL-16232G (app B, 1.1-4).
- (2) Steel 4340 with manganese-phosphated coating MIL-DTL-16232G.

<sup>1</sup>AMS 4377 surface treated in accordance with AMS-M-3171, Type III.

c. Immerse the test specimens in a beaker of acetone, Type II, conforming to ASTM D-235 (app B, ref 1.1-5) at room temperature and swab the surface of the individual specimens thoroughly using clean forceps to hold the test specimen and a cotton swab.

d. Shake off the excess solvent. Transfer and immerse the test specimens separately several times in a beaker of methylethylketone (MEK). Shake off the excess MEK and dry in a low-temperature oven at  $120 \pm 5$  °C ( $248 \pm 5$  °F) for 15 minutes. Remove to desiccator and cool to room temperature.

e. Identify each panel with No. 1, 2, 3, or 4. Each test specimen is then weighed to the nearest 0.1 mg.

f. Four test specimens from each material type listed in paragraph b (phosphate coatings) are subjected to a Salt Fog test as outlined in ASTM B-117-95 (app B, ref 1.1-6), Standard Practice for Operating Salt Spray (Fog) Apparatus. The test is conducted to failure and that time is recorded.

g. A container of the manufacturer's suggested maximum use concentration of the cleaning compound is prepared for immersing the test specimens. The volume of the cleaner solution is related to the area of the test specimen immersed by 8 mL cleaner per 1-cm<sup>2</sup> test specimen. Take the total area of the specimens as 28.2 cm<sup>2</sup> (4.4 in.<sup>2</sup>).

h. Separate containers are used for each of the materials with new manufacturer's suggested working concentrations of the cleaning compound to prevent any contamination. Use fresh solution for each set of replicates.

i. Testing should be conducted at  $38 \pm 3$  °C ( $100 \pm 5$  °F).

j. Three test specimens of each material type are immersed into the manufacturer's maximum recommended use concentration of the cleaning compound and allowed to soak for 24 hours. Maintain at the required temperature for the prescribed exposure period. The fourth test specimen is used as the control specimen for the test. In addition, three specimens from each of the materials listed in paragraph b (phosphate coatings) are immersed in P-D-680.

k. After 24 hours, the test specimens are removed from the manufacturer's maximum recommended use concentration of the cleaning compound.

l. The test specimens are rinsed under hot tap water (49 to 60 °C (120 to 140 °F)).

m. The test specimens are then rinsed in dionized water conforming to Specification ASTM D-1193, Type IV at ambient (room) temperature.

n. The test specimens are then rinsed with a stream of acetone, conforming to Specification ASTM D 329 (app B, ref 1.1-7), from a wash bottle and oven dried at 120 °C (250 °F).



o. After drying, the test specimens are placed in a container with desiccant until cooled to ambient (room) temperature.

p. The test specimens are then individually weighed to the nearest 0.1 mg.

q. The following visual observations should be conducted on each test specimen in comparison to an unexposed specimen:

(1) Discoloration and dulling.

(2) Etching.

(3) Presence of accretions and relative amounts.

(4) Pitting.

(5) Presence of selective or localized attack.

r. The three test specimens are then immersed in the same manufacturer's suggested working concentration of the cleaning compound for an additional 144 hours.

s. The steps in paragraphs k through q are repeated.

t. Eight of the test specimens from each listed in paragraph b (phosphate coatings), four of which had been immersed in cleaner and four immersed in P-D-680, are subjected to the Salt Fog test outlined in ASTM B-117-95. All test specimens should be photographically documented immediately upon completion of the test.

u. Report the following information for each test performed:

(1) Summary of test methods and any deviations from the protocol.

(2) Identification of sample material alloy(s), product temper, and selection of thickness of material tested including reference to product specification.

(3) Specimen details; type and dimensions of test specimen and number of replicates.

(4) Identification of solution tested, concentration used, and diluent used.

(5) Test conditions; temperature, exposure time, and, humidity.

(6) Identification of testing laboratory and responsible technical point of contact.

(7) Individual and average test results.

(8) Results of visual inspections, observations, and discussion of specimen condition.

(9) Photographic documentation of specimen conditions (specifically any staining, evidence of general corrosion, etching, pitting, or localized attack).

### **1.1.2 Hot Dip Galvanized Corrosion**

#### **Objective**

The objective of this test is to determine the total immersion characteristics of hot dip galvanized steel immersed in the manufacturer's suggested working concentration of the cleaning compound.

#### **Criterion**

The manufacturer's suggested working concentration of the cleaning compound shall not show any indication of staining, etching, pitting, or localized attack on the test panels, or cause weight change to an average of three (3) test panels greater than  $0.14 \text{ mg/cm}^2$  for 24 hours.

#### **Test Procedures**

The total immersion corrosion of Society of Automotive Engineers (SAE) AMS 5046 steel (app B, ref 1.1-8) (1020 steel) hot dip galvanized per ASTM A-153 (app B, ref 1.1-9) caused by the manufacturer's suggested working concentration of the cleaning compound is determined using ASTM F-483-98 (app B, ref 1.1-3), Standard Test Method for Total Immersion Corrosion Test for Aircraft Maintenance Chemicals.

a. Four test specimens, 50.8 by 25.4 by 1.6 mm (2 by 1 by 0.06 in.) with a 3.2-mm (0.125 in.) diameter mounting hole suitably located at one end of the specimen, are prepared from the same sheet stock.

b. Immerse the test specimens in a beaker of mineral spirits, Type II, conforming to ASTM D-235 (app B, ref 1.1-5) at room temperature and swab the surface of the individual specimens thoroughly using clean forceps to hold the test specimen and a cotton swab.

c. Shake off the excess solvent. Transfer and immerse the test specimens separately several times in a beaker of MEK. Shake off the excess MEK and dry in a low-temperature oven at  $120 \pm 5^\circ\text{C}$  ( $248 \pm 5^\circ\text{F}$ ) for 15 minutes. Remove to desiccator and cool to room temperature.

d. Identify each panel with No. 1, 2, 3, or 4. Each test specimen is then weighed to the nearest 0.1 mg.

e. A container of the manufacturer's suggested maximum use concentration of the cleaning compound is prepared for immersing the test specimens. The volume of the cleaner solution is related to the area of the test specimen immersed by 8 mL cleaner per  $1\text{-cm}^2$  test specimen. Take the total area of the specimens as  $28.2 \text{ cm}^2$  ( $4.4 \text{ in}^2$ ).

f. Testing should be conducted at  $38 \pm 3^\circ\text{C}$  ( $100 \pm 5^\circ\text{F}$ ).

g. Three test specimens are immersed into the manufacturer's maximum recommended use concentration of the cleaning compound and allowed to soak for 24 hours. Maintain at the required temperature for the prescribed exposure period. The fourth test specimen is used as the control specimen for the test.

h. After 24 hours, the test specimens are removed from the manufacturer's maximum recommended use concentration of the cleaning compound.

i. The test specimens are rinsed under hot tap water (49 to 60 °C (120 to 140 °F)).

j. The test specimens are then rinsed in dionized water conforming to ASTM D-1193, Type IV (app B, ref 1.1-10) at ambient (room) temperature.

k. The test specimens are then rinsed with a stream of acetone, conforming to Specification ASTM-D 329 (app B, ref 1.1-7), from a wash bottle and oven dried at 120 °C (250 °F).

l. After drying, the test specimens are placed in a container with desiccant until cooled to ambient (room) temperature.

m. The test specimens are then individually weighed to the nearest 0.1 mg.

n. The following visual observations should be conducted on each test specimen in comparison to an unexposed specimen:

- (1) Discoloration and dulling.
- (2) Etching.
- (3) Presence of accretions and relative amounts.
- (4) Pitting.
- (5) Presence of selective or localized attack.

o. Report the following information for each test performed:

- (1) Summary of test methods and any deviations from the protocol.
- (2) Identification of sample material alloy(s), product temper and selection of thickness of material tested including reference to product specification.
- (3) Specimen details; type and dimensions of test specimen and number of replicates.
- (4) Identification of solution tested, concentration used, and diluent used.
- (5) Test conditions; temperature, exposure time, and humidity.

- (6) Identification of testing laboratory and responsible technical point of contact.
- (7) Individual and average test results.
- (8) Results of visual inspections, observations and discussion of specimen condition.
- (9) Photographic documentation of specimen conditions (specifically any staining, evidence of general corrosion, etching, pitting, or localized attack).

### **1.1.3 Low - Embrittling Cadmium Plate Corrosion**

#### **Objective**

The objective of this test is to determine the corrosive effects of the manufacturer's maximum suggested use concentration of the cleaning compound on low-embrittling cadmium plating used on aircraft high-strength steel, under conditions of total immersion by quantitative measurements of weight change.

#### **Criterion**

The manufacturer's maximum suggested use concentration shall not cause weight change of the average of the three (3) test panels greater than  $0.14 \text{ mg/cm}^2/24 \text{ hr}$ .

#### **Test Procedure**

The corrosive effect of the manufacturer's maximum recommended suggested use concentration of the cleaning compound is determined according to the procedure given in ASTM F-1111-88 (1998) (app B, ref 1.1-11), Standard Test Method for Corrosion of Low-Embrittling Cadmium Plate by Aircraft Maintenance Chemicals.

a. Three test specimens shall be prepared of 4130 steel in accordance with MIL-S-18729 (app B, ref 1.1-12) condition N, measuring 25.4 by 50.8 by 1.22 mm (1 by 2 by 0.048 in.) and cadmium plated in accordance with Appendix XI of ASTM F-1111-88 (1998). The electro-deposited plating shall have a minimum thickness of 0.13 mm (0.0005 in.).

b. Using a stiff brush, brush off loose cadmium plate, being careful to brush only as hard as necessary to remove loose cadmium plate. Immerse the test specimen in a beaker of 1.1.1 - trichloroethane maintained at a temperature of  $66 \pm 3 \text{ }^\circ\text{C}$  ( $150 \pm 5 \text{ }^\circ\text{F}$ ) and swab the surface of each specimen thoroughly using clean forceps to hold the specimen and the cotton swabs.

c. Shake off excess solvent. Transfer and immerse the test specimens separately several times in a beaker of MEK.

d. Shake off excess MEK and dry in an oven at  $110 \pm 2 \text{ }^\circ\text{C}$  ( $230 \pm 4 \text{ }^\circ\text{F}$ ) for 1 hour.

e. Prepare a container of the manufacturer's maximum use concentration of the cleaning compound. The volume of the test solution shall be such that the ratio of the area of the immersed metal to the volume of the solution is 25 mL of solution per 625 mm<sup>2</sup> (1 in.<sup>2</sup>) of specimen surface. Use deionized water (ASTM D-1193 (app B, ref 1.1-10), Type IV) to dilute the cleaner as required to achieve the test concentration.

f. Remove the specimens from the drying oven, allow them to cool to room temperature in a dessicator, then weigh to the nearest 0.1 mg.

g. Preheat the vessel containing the cleaner solution to the test temperature of  $35 \pm 1$  °C ( $95 \pm 2$  °F).

h. Transfer the specimens to the vessel containing the preheated cleaner solution and seal the vessel to prevent loss of vapor. Maintain the cleaner solution at the required test temperature and expose for a period of 24 hours.

i. Remove the test specimens at the end of the 24 hour exposure period.

j. Hold the specimen in forceps and rinse thoroughly in a 1-liter beaker into which tap water is flowing rapidly.

k. Rinse thoroughly in deionized water (ASTM D-1193, Type IV) at room temperature.

l. Rinse with a stream of acetone from a wash bottle. Shake free from acetone and dry.

m. Place the specimens in an oven at  $110 \pm 2$  °C ( $230 \pm 4$  °F) for 1 hour and allow to cool to room temperature in a dessicator.

n. Reweigh the specimens to the nearest 0.1 mg and record.

o. Report the following information for each test performed.

(1) Summary of test methods and any deviations from the protocol.

(2) Identification of sample material alloy(s), product temper and selection of thickness of material tested including reference to product specification.

(3) Specimen details; type and dimensions of test specimen and number of replicates.

(4) Identification of solution tested, concentration used, and diluent used.

(5) Test conditions; temperature, exposure time, and humidity.

(6) Identification of testing laboratory and responsible technical point of contact.

(7) Individual and average test results.

(8) Results of visual inspections, observations, and discussion of specimen condition.

(9) Photographic documentation of specimen conditions (specifically any staining, evidence of general corrosion, etching, pitting, or localized attack).

#### **1.1.4 Elevated Temperature Corrosion/Stock Loss**

##### **Objective**

The objective of this test is to determine the general corrosion and stock loss characteristics of cleaner systems, which use a heated process.

##### **Criterion**

The manufacturer's maximum recommended concentration plus 10% of the cleaning compound tested at the maximum recommended operating temperature plus 25 °F shall not show any indication of corrosion on the test panels or cause any average stock loss greater than amounts given in Table 1.1-2.

##### **Test Procedures**

The stock loss caused by the cleaning compound is determined according to the procedure given in SAE ARP 1755-00 (app B, ref 1.1-13) (Effects of Cleaning Agents on Aircraft Engine Materials; Stock Loss Test Method) with the exceptions noted: 1) Test duration shall be 8 hours, 2) Test temperatures shall be maximum recommended temperature plus 25 °F, not to exceed boiling point minus 5 °F, 3) Concentration shall be maximum recommended plus 10 percent.

a. Four test panels, 51 by 127 by 1.6 mm (2 by 5 by 0.06 in.) are prepared from the same sheet stock of each of the following materials:

- (1) PH 13-8 Mo (high strength steel).
- (2) Maraging C-250 (high strength steel).
- (3) Magnesium (AZ31B-H24)<sup>1</sup>.
- (4) Aluminum 2024 T3 (non-clad).
- (5) Aluminum 5052 H32 (non-clad).
- (6) Aluminum 6061 T5 (non-clad).
- (7) Aluminum 7075 (non-clad).
- (8) Titanium 6AL-4V.

<sup>1</sup>AMS 4377 surface treated in accordance with AMS-M-3171, Type III.

(9) Steel 4340.

(10) Copper alloy (brass) UNS C3600.

(11) Copper alloy UNS C10 100 H02 (half hard).

(12) Silver plated steel (MIL-STD-171E, para 5.1) (app B, ref 1.1-14).

b. Prepare the panels as follows:

(1) Prepare 51- by 127-cm (2- by 5-in.) panels from sheet or strip or transverse cross-section disks with parallel ground faces cut from conveniently sized bars and drill or punch a 3.2-cm (1/8-in.) diameter hole near one end if needed for suspension.

(2) Deburr edges after cutting and drilling or punching.

(3) Wet abrasive blast test specimens all over, using approved alumina or silica abrasive or nonsilicone treated glass beads nominally 0.02 to 0.08 cm (0.001 to 0.003 in.) in diameter. Machine air pressure to be 414 to 689 kPa (60 to 100 psi). Specimens may be prepared using dry blasting methods with 500 mesh alumina. Air pressure requirements are 172 to 207 kPa (25 to 30 psi) on a direct pressure machine or 345 to 414 kPa (50 to 60 psi) using a suction type dry blasting machine.

(4) Number each individual panel for identification.

c. Degrease using any degreasing method approved by engine manufacturer or overhaul facility.

d. Rinse in alcohol or acetone.

e. Air dry for 15 to 20 minutes or oven dry at a temperature below 93 °C (200 °F) and air cool, and immediately weigh panel or disk to nearest milligram and record weight ( $W_1$ ).

f. Suspend test panel or disk not less than 51 cm (2 in.) below the surface of the cleaning solution being tested for the time specified.

g. In order to avoid possible error by galvanic action between the specimen and the tank or other grounding source, the specimen should be suspended without contact in the cleaning solution using a corrosion-resistant steel wire insulated from the tank or any grounding source.

h. Rinse in clean, cold tap water.

i. Brush with soft brush, apply pressure spray, or ultrasonically rinse.

j. Rinse in clean, cold tap water.

k. Rinse in clean, hot tap water.

- l. Discard wire hanger and rinse or ultrasonically rinse specimen in alcohol or acetone.
- m. Air dry for 15 to 20 minutes or oven dry at a temperature below 93 °C (200 °F) and air cool, and immediately weigh panel or disk to nearest milligram and record weight ( $W_F$ ).
- n. Determine the weight lost in the cleaning solution by subtracting weight ( $W_F$ ) in paragraph m from weight in paragraph e.
- o. From weight loss of paragraph n, total surface area of test specimen, and density of metal alloy shown in Table 1.1-2, determine stock loss in the cleaning solution using Equation 1.

$$\text{Stock Loss} = \frac{W_I - W_F}{D \times A}$$

where:

$W_I$  = initial weight of specimen.

$W_F$  = final weight of specimens.

$D$  = density of specimen.

$A$  = area of specimen.

TABLE 1.1-2. DENSITY OF TEST MATERIALS

Material	Density, g/c <sup>3</sup>
PH 13-8 Mo	7.72
Maraging C250	8.00
Magnesium (AZ318-H24) <sup>a</sup>	1.77
AL 7075 (non clad)	2.81
Titanium 6Al-4V	4.43
Steel 4340	7.85
Copper Alloy (brass) UNS 3600	8.49
Copper Alloy UNS C10100 HO2 (half hard)	8.94
Silver Plated Steel (MIL-STD-171E, Para 5.1)	>7.85 (depending on thickness of plating)

<sup>a</sup>AMS 4377 surface treated in accordance with AMS-M-3171, Type III.

p. Report any visual general corrosion, preferential grain boundary attack, pitting, corrosion or stock loss (in units of micrometers as shown in table 1.1-3) and the cleaner concentration, temperature, and processing time utilized. Preferential grain boundary attack, pitting corrosion or stock loss above the allowable limit provided should be cause for rejection.



TABLE 1.1-3. ALLOWABLE CORROSION STOCK LOSS

Alloys	Stock Loss <sup>a</sup> $\mu\text{m}/8 \text{ hrs}$
Maraging C-250	0.048
PH 13-8 Mo	.048
Steel 4340	.048
Titanium 6Al-4V	.019
Al 7075-T6 (non-clad)	.048
Magnesium (AZ31B-H24) <sup>b</sup>	.048
AL 2024 T3	.048
AL 5052 H32	.048
AL 6061 T5	.048

<sup>a</sup>Average of three panels.

<sup>b</sup>AMS 4377 surface treated in accordance with AMS-M-3171, Type III.

q. Report the following information for each test performed:

- (1) Summary of test methods and any deviations from the protocol.
- (2) Identification of sample material alloy(s), product temper, and selection of thickness of material tested including reference to product specification.
- (3) Specimen details; type and dimensions of test specimen and number of replicates.
- (4) Identification of solution tested, concentration used, and diluent used.
- (5) Test conditions; temperature, exposure time, and humidity.
- (6) Identification of testing laboratory and responsible technical point of contact.
- (7) Individual and average test results.
- (8) Results of visual inspections, observations, and discussion of specimen condition.
- (9) Photographic documentation of specimen conditions (specifically any staining, evidence of general corrosion, etching, pitting, or localized attack).

### 1.1.5 Sandwich Corrosion

#### Objective

The objective of this test is to determine the sandwich corrosion characteristics of the manufacturer's suggested working concentration of the cleaning compound.

## Criterion

The manufacturer's suggested working concentration of the cleaning compound shall not cause a corrosion rating greater than two (2) on any test panel (Test Protocol). The corrosion rating on the set of test panels from the test solution group shall not be worse than the corrosion rating of the Reagent water, control group. Any corrosion in excess of that shown by the control group shall be cause for rejection. Pitting corrosion of any panel gets a severity rating of 4.

## Test Procedures

The sandwich corrosion caused by the manufacturer's suggested working concentration of the cleaning compound is determined using ASTM F-1110-90 (1998) (app B, ref 1.1-15), Standard Test Method for Sandwich Corrosion Test.

a. Sixteen test panels, 50 by 100 by 1.5 mm (2 by 4 by 0.06 in.), are prepared from the same sheet stock of each of the materials listed below:

- (1) PH 13-8 Mo (high-strength steel).
- (2) Maraging C-250 (high-strength steel).
- (3) Aluminum 2024-T3 (non-clad).
- (4) Aluminum 5052-H32 (non-clad).
- (5) Aluminum 6061-T5 (non-clad).
- (6) Aluminum 7075-T6 (non-clad).
- (7) Titanium 6AL-4V.
- (8) Steel 4340.
- (9) Magnesium (AZ31B-H24)<sup>1</sup>.
- (10) 519 Cadmium-plated AISI/SAE 4340 steel.
- (11) Steel 4340, zinc phosphated per MIL DTL-16232G (an additional set of eight test coupons of this material should be made for testing against P-D-680 Type II).
- (12) Silver plated steel (MIL-STD-171E, para 5.1).

b. Prepare two sets of test panels. A test panel set shall consist of eight individual test coupons, sandwiched together in pairs of coupons of the same alloy and the same surface treatment, to provide four test coupon sandwiches for each test condition.

<sup>1</sup>AMS 4377 surface treated in accordance with AMS-M-3171, Type III.

c. The coupons are individually identified by impression stamping or other suitable permanent method.

d. The aluminum 7075-T6 (non-clad) coupons are anodized in accordance with MIL-A-8625C, Type 1 (app B, ref 1.1-16).

e. The test panels are cleaned by solvent, wiping or vapor degreasing. Do not use caustic or acid cleaners. Remove ink stamped markings from panels. Do not use abrasive materials to clean the panels.

f. Cut a piece of glass filter paper (use Whatman GFA or equal filter paper made from glass fibers, 11 or 13 cms) to approximate 25 by 75 mm (1 by 3 in.)

g. Fit this piece over one of the coupons. Add the test solution at the manufacturer's maximum recommended use concentration to the paper until saturated. Cover the wet paper with the second coupon of the sandwich pair. Repeat the operation for each of the coupon sets in the group.

h. Prepare a second group of panels as outlined in g, except apply reagent water (specification ASTM D-1193-91 (app B, ref 1.1-10), Type IV) to the filter paper between the panels.

i. During each day of the test, the test coupon pairs are exposed to air oven heat and humidity as specified in Table 1.1-4.

TABLE 1.1-4. SANDWICH CORROSION EXPOSURE  
CYCLES AT  $37.7 \pm 2.8$  °C ( $100 \pm 5$  °F)

Step No.	Exposure Time, hr ( $\pm 0.5$ )	Relative Humidity, %
1	8	Ambient
2	16	95 to 100
3	8	Ambient
4	16	95 to 100
5	8	Ambient
6	16	95 to 100
7	8	Ambient
8	16	95 to 100
9	8	Ambient
10	64	95 to 100

j. Each set of test coupon pairs individually, not stacked, is exposed in a horizontal position.

k. After completing the exposure cycles, the test coupon pairs are rinsed in warm tap water and scrubbed lightly with a soft, nonmetallic bristle brush.

l. The test coupon pairs are then dried.

m. Each test coupon is examined under a 10X magnification.

n. The observations are rated using the following convention:

(1) 0 - no visible corrosion (no corrosion).

(2) 1 - very slight corrosion or discoloration (up to 5 percent of the surface area corroded).

(3) 2 - slight corrosion (5 to 10 percent of the surface area corroded).

(4) 3 - moderate corrosion (10 to 25 percent of the surface area corroded).

(5) 4 - extensive corrosion or pitting (25 percent or more of the surface area corroded).

o. Compare the corrosion rating on the set of panels from the test solution group with those from the third, Reagent water, control group. Any corrosion in excess of that shown by the control group shall be cause for rejection. Give pitting corrosion of any panel a severity rating of 4. Compare only those surfaces which were under the filter paper. Pitting is defined in ASTM G-46 (app B, ref 1.1-17).

p. The steps in paragraphs b through n are repeated for the additional eight test coupons of steel 4340 zinc phosphated. P-D-680 Type II is substituted for the manufacturer's suggested working concentration of the cleaning compound in the step in paragraph g. The control from the first set is used for this set. All test coupons should be photographically documented immediately upon completion of the test.

q. Report the following information for each test performed:

(1) Summary of test methods and any deviations from the protocol.

(2) Identification of sample material alloy(s), product temper, and selection of thickness of material tested including reference to product specification.

(3) Specimen details; type and dimensions of test specimen and number of replicates.

(4) Identification of solution tested, concentration used, and diluent used.

(5) Test conditions; temperature, exposure time, and humidity.

(6) Identification of testing laboratory and responsible technical point of contact.

(7) Individual and average test results.

(8) Results of visual inspections, observations, and discussion of specimen condition.

(9) Photographic documentation of specimen conditions (specifically any staining, evidence of general corrosion, etching, pitting, or localized attack).

### **1.1.6 Hydrogen Embrittlement**

#### **Objective**

The objective of this test is to determine the hydrogen embrittlement characteristics of the manufacturer's suggested working concentration of the cleaning compound.

#### **Criterion**

The manufacturer's suggested working concentration of the cleaning compound shall not cause hydrogen embrittlement of cadmium plated ANSI 4340 steel (Test Protocol).

#### **Test Procedures**

The hydrogen embrittlement effect that the manufacturer's suggested working concentration of the cleaning compound has on materials is determined using ASTM F-519-97 (app B, ref 1.1-18), Standard Test Method for Mechanical Hydrogen Embrittlement Testing of Plating Processes and Aircraft Maintenance Chemicals.

a. Prepare test specimens, Type 1d, according to the requirements of ASTM F-519-97, paragraph 7.2 and Annex A.2.3.

b. All specimens must be taken from a single lot.

(1) A lot shall consist of only those specimens cut from the same heat of steel in the same orientation, heat treated together in the same furnace, quenched and tempered together, and subjected to the same manufacturing processes.

(2) All notched specimens shall be suitable for test purposes if the sampling and inspection results conform to the requirements of the lot acceptance criteria for Type 1d notched specimens, as stated in ASTM F-519-97, Table 1.

c. The sensitivity to hydrogen embrittlement must be demonstrated for each heat of American National Standards Institute (AISI) 4340 steel by exposing six trial specimens to two different embrittling environments after manufacture and inspection in accordance with above.

(1) Determine the average diameter of the notched C-ring at fracture with unexposed specimens (as shown in ASTM F-519-97, table 2) with the loading device in ASTM F-519-97, Figure 9 or an equivalent method. Stress levels are indicated as percentages of the change in diameter required to fracture the specimens. These specimens determine the bend notch fracture strength or lot acceptance test values.

(2) Three specimens shall be electroplated under the highly embrittling conditions produced in a cadmium cyanide bath by ASTM F-519-97, Treatment A (table 2). Each heat of steel shall be of suitable sensitivity only if all three specimens plated by ASTM F-519-97, Treatment A fracture within 24 hours and none of the three specimens plated by ASTM F-519-97, Treatment B fracture within 200 hours after applying the sustained load of 75, percent of the bend notch fracture strength.

d. Certification of lot conformance to the above requirements must be included in the data package for the results of the Hydrogen Embrittlement Test.

e. Three test specimens manufactured and plated in accordance with ASTM F-519-97, Treatment B shall be tested to determine the hydrogen embrittling effect of the test cleaner.

f. The test shall be conducted in air or any other controlled environment using an appropriate inert container and fixture that is suitably electrically isolated from the specimen or compensated to prevent a galvanic coupling. Test the cleaner at the maximum specified dilution to determine the full embrittling effect of exposure in service. Conduct all tests at the operating service temperature of the test cleaner.

g. Load the test specimens using the self-loading bolt device. The nut and bolt shall be cadmium plated to avoid any galvanic reaction with the test specimen. Apply 65 percent of the bend notch fracture strength. Stress levels can be related to the percentage change in diameter required to fracture the specimens. (Previously determined during lot acceptance testing.)

h. Each Type 1d specimen shall be immersed in a separate container with sufficient quantity of the test cleaner solution to completely cover the specimen.

i. The test cleaner shall be considered nonembrittling if none of the immersed specimens fail within 150 hours after immersion into the chemical. Record the time to failure if less than 150 hours. The test may be discontinued after 150 hours.

j. If only one of the five specimens fractures within the exposure time, continue to step load the remaining specimens, every hour in 5 percent increments to 90 percent of the fracture tensile/bend load after completion of a 150 hour sustained load. After 1 hour at 90 percent, the cleaner shall be considered nonembrittling if no fracture occurs.

k. Report the following information for each test performed:

(1) Summary of test methods and any deviations from the protocol.

(2) Identification of sample material alloy(s), product temper, and selection of thickness of material tested including reference to product specification.

(3) Specimen details; type and dimensions of test specimen and number of replicates.

(4) Identification of solution tested, concentration used, and diluent used.

- (5) Test conditions; temperature, exposure time, and humidity.
- (6) Identification of testing laboratory and responsible technical point of contact.
- (7) Individual and average test results.
- (8) Results of visual inspections, observations, and discussion of specimen condition.
- (9) Photographic documentation of specimen conditions (specifically any staining, evidence of general corrosion, etching, pitting, or localized attack).

#### **1.1.7 Effects On Unpainted Surfaces**

##### **Objective**

The objective of this test is to determine the effects on unpainted surfaces of the manufacturer's suggested working concentration of the cleaning compound. This method is used to ensure that candidate cleaners do not leave a residue or cosmetic stain which, on drying would leave a permanent stain requiring polishing to remove.

##### **Criterion**

The manufacturer's suggested working concentration of the cleaning compound shall not cause streaking, stains or other deposits on unpainted surfaces that cannot be easily removed with water (Test Protocol).

##### **Test Procedures**

The effects of the manufacturer's suggested working concentration of the cleaning compound on the unpainted surfaces is determined using ASTM F-485-98 (app B, ref 1.1-19), Standard Test Method for Effects of Cleaners on Unpainted Aircraft Surfaces, modified by the Test Plan.

a. Two test panels, 50 by 152 by 0.51 mm (2 by 6 by 0.020 in.), are prepared from each of the following materials:

- (1) PH 13-8 Mo (high-strength steel).
- (2) Maraging C-250 (high-strength steel).
- (3) Aluminum 2024 T-3 (non-clad).
- (4) Aluminum 5052 H32 (non-clad).
- (5) Aluminum 6061 T-5 (non-clad).

- (6) Aluminum 7075-T6 (non-clad).
  - (7) Titanium 6AL-4V.
  - (8) Steel 4340.
  - (9) Magnesium (AZ31B-H24)<sup>1</sup>.
  - (10) Silver plated steel (MIL STD-171E, para 5.1).
- b. Each test panel is cleaned with MEK.
  - c. The test panels are allowed to dry at ambient (room) conditions.
  - d. Two test panels from each material are immersed for 4 minutes in enough of the manufacturer's suggested working concentration of the cleaning compound to cover one-half of the test specimen.
  - e. The test panels are removed from the test solution.
  - f. The test specimens are then placed immediately in a mechanical convection oven at 45° from the horizontal. The oven temperature should be maintained at  $65.5 \pm 2$  °C ( $150 \pm 5$  °F).
  - g. The test specimens are allowed to remain in the oven for 30 minutes.
  - h. Remove the panels from the oven and cool to room temperature.
  - i. Rinse on each side within 15 minutes under running tap water for 1 minute without using mechanical agitation.
  - j. Rinse each side of each test panel with distilled or deionized water from a squeeze bottle for 15 seconds.
  - k. The test panels are then allowed to air dry for 30 minutes at ambient (room) conditions.
  - l. The treated and untreated sections of each test specimen are visually examined for stains or residue. All test specimens should be photographically documented immediately upon termination of the test.
  - m. Report the following information for each test performed:
    - (1) Summary of test methods and any deviations from the protocol.

<sup>1</sup>AMS 4377 surface treated in accordance with AMS-M-3171, Type III.



(2) Identification of sample material alloy(s), product temper, and selection of thickness of material tested including reference to product specification.

(3) Specimen details; type and dimensions of test specimen, and number of replicates.

(4) Identification of solution tested, concentration used, and diluent used.

(5) Test conditions; temperature, exposure time, and humidity.

(6) Identification of testing laboratory and responsible technical point of contact.

(7) Individual and average test results.

(8) Results of visual inspections, observations, and discussion of specimen condition.

(9) Photographic documentation of specimen conditions (specifically any staining, evidence of general corrosion, etching, pitting, or localized attack).

### **1.1.8 Stress Corrosion**

#### **Objective**

The objective of this test is to determine the stress corrosion characteristics of the manufacturer's suggested working concentration of the cleaning compound.

#### **Criterion**

The manufacturer's suggested working concentration of the cleaning compound shall not cause stress corrosion (Test Protocol).

#### **Test Procedures**

The stress corrosion caused by the manufacturer's suggested working concentration of the cleaning compound is determined using ASTM G-30-97 (app B, ref 1.1-20), type (a) test specimens, Standard Practice for Making and Using U-Bend Stress-Corrosion Test Specimens and the ASTM G-44-99 (app B, ref 1.1-21) Test Method, Standard Practice for Evaluating Stress Corrosion Cracking Resistance of Metals and Alloys by Alternate Immersion in 3.5 percent Sodium Chloride Solution, modified in the following manner. The manufacturer's suggested working concentration of the cleaning compound is substituted for the 3.5 percent sodium chloride solution, a 10-minute soak and 50-minute drying cycle are substituted for a 20-minute soak and 100 minute drying cycle, and the temperature will be 40.6 °C (105 °F) instead of 27 °C (80 °F) at 45 ± 10-percent relative humidity. These modifications are specified in ASTM D-6361-98 (app B, ref 1.1-22), Standard Guide for Selecting Cleaning Agents and Processes, Appendix X2, Modification of Practice G-44.

a. Four specimens (three test and one control) should be fabricated in accordance with ASTM G-30-97, type (a) U-bend from each of the following materials:

(1) PH 13-8 Mo (high-strength steel).

(2) Maraging C-250 (high-strength steel).

(3) Aluminum 2024 T-3 (non-clad).

(4) Aluminum 5052 H32 (non-clad).

(5) Aluminum 6061 T-5 (non-clad).

(6) Aluminum 7075-T6 (non-clad).

(7) Titanium 6AL-4V. (Follow the procedure given in ASTM F-945 (app B, ref 1.1-23) using Method A heat treatment.)

(8) Steel 4340.

(9) Magnesium (AZ31B-H24)<sup>1</sup>.

(10) Steel 4340, Manganese Phosphate Coating per MIL DTL-16232G (app B, ref 1.1-4).

(11) Silver plated steel (MIL STD-171E, para 5.1).

b. Leave one stressed specimens untreated to establish validity of the sheet material.

c. All of the precautions are followed as outlined in ASTM G-44-99.

d. All testing is conducted at the manufacturer's suggested operating temperature, generally 40 to 50 °C (100 to 120 °F) for aqueous based cleaners.

e. Maintain the entire cycling mechanism, the test solution and the drying environment, at the manufacturer's recommended operating temperature.

f. Use sufficient test solution to cover the stress portion of the test specimens throughout the 20-minute immersion period.

g. Maintain the level in the immersion baths by addition of deionized water. On a 7-day interval replace the immersion bath test solution with fresh test solution.

h. This cycle is continued for 24 hours per day for 90 days.

<sup>1</sup>AMS 4377 surface treated in accordance with AMS-M-3171, Type III.

i. After exposure, specimens should be rinsed with water and then cleaned as soon as possible. It is important that the specimens be cleaned as thoroughly as possible by recommended methods of cleaning, such as ASTM G-1.

j. Test specimens that do not show obvious cracks should be examined at 20X. If the untreated (control) specimens are cracked the results of the stress corrosion test are invalid. Metallographic examination may be required to verify freedom from cracking.

k. Representative failed specimens should be examined metallographically to verify failure was caused by stress-corrosion cracking.

l. Metallographic inspection shall be conducted as follows: Make a cross section of each specimen at the bend normal to the bend axis (parallel to the test panel long axis). Cut the specimens using a saw that produces a smooth cut with minimal disturbance of specimen edges. Make the cut approximately at the center axis in line with the holes. The metallographic section shall encompass material from the bend to a point approximately 13 mm (0.5 in.) from the bend. Examine the cut surface over the 13 mm (0.5 in.) distance on both sides of the bend zone at 500X.

m. Report the following information for each test performed:

(1) Summary of test methods and any deviations from the protocol.

(2) Identification of sample material alloy(s), product temper, and selection of thickness of material tested including reference to product specification.

(3) Specimen details; type and dimensions of test specimen and number of replicates.

(4) Identification of solution tested, concentration used, and diluent used.

(5) Test conditions; temperature, exposure time, and humidity.

(6) Identification of testing laboratory and responsible technical point of contact.

(7) Individual and average test results.

(8) Results of visual inspections, observations, and discussion of specimen condition.

(9) Photographic documentation of specimen conditions (specifically any staining, evidence of general corrosion, etching, pitting, or localized attack).

### **1.1.9 Copper Corrosion**

#### **Objective**

The objective of this test is to assess the relative degree of corrosivity of the manufacturer's suggested working concentration of the cleaning compound.

## Criterion

The manufacturer's suggested working concentration of the cleaning compound shall not cause a copper corrosion rating higher than 1a (Test Protocol).

## Test Procedures

The copper corrosion characteristics of the manufacturer's suggested working concentration of the cleaning compound are determined using ASTM D-130-94 (2000) (app B, ref 1.1-24) Standard Test Method for Detection of Copper Corrosion from Petroleum Products by the Copper Strip Tarnish Test.

a. Two specimens shall be examined for each of the test conditions detailed below. The specimens shall be strips 12.5 mm (1/2 in.) wide, 1.5 to 3.0 mm (1/16 to 1/8 in.) thick, cut 75 mm (3 in.) long from smooth-surfaced, hard-tempered, cold-finished copper of 99.9+ percent purity. The strips may be used repeatedly but should be discarded when the surfaces become deformed on handling.

b. All six surfaces of each specimen should be prepared using silicon carbide paper to remove all surface blemishes. At all times when handling the test strips protect the strip from contact with fingers with an ashless filter paper. Finish with 65 micron (240 grit) silicon paper removing all marks from previous grades of paper. Upon completion of the final paper immerse the specimen in solvent until immediately before testing.

c. Immediately before testing remove the test strip from the wash solvent and polish the ends and sides with 105 micron (150 grit) silicon carbide grains picked up from a clean glass plate with a pad of cotton moistened with a drop of wash solvent. Wipe vigorously with fresh cotton pads and handle strips only with stainless steel forceps. Polish the main surfaces of the strip holding the strip in a vice as necessary. Polish in the direction of the long axis of the strip and clean all metal dust by rubbing vigorously with clean cotton pads until a fresh pad remains clean.

d. When the strip is uniformly polished and clean, immediately immerse it in the test solution.

e. Thirty milliliters of the manufacturer's suggested working concentration of the cleaning compound is placed in each of two 25- by 150-mm test tubes.

f. Within 1 minute of completing final preparation (polishing), the test specimens are placed into the test tubes with the manufacturer's suggested working concentration of the cleaning compound. Stopper the test tube with a vented cork.

g. The test tubes should be placed into a water bath maintained at the manufacturer's recommended operating temperature for 3 hours and the contents of the test tube should be protected from strong light during the test.

h. After 3 hours  $\pm$  5 minutes in the bath, the test tubes are removed from the bath and the contents are emptied into a clean beaker.

i. Immediately, the test specimens are removed with stainless steel forceps and immersed in wash solvent, then removed and blotted dry.

j. The specimens are then inspected for evidence of tarnishing, pitting, and corrosion and compared with the ASTM copper strip corrosion standard. Report the corrosiveness in accordance with ASTM D-130-94 (2000), Table 1.

k. Repeat the complete procedure for the following additional conditions:

(1) Three hour exposure at 100 °C (212 °F).

(2) Twenty-four hours exposure at the manufacturer's recommended operating temperature.

(3) Twenty-four hours exposure at 100 °C (212 °F).

l. Report the following information for each test performed:

(1) Summary of test methods and any deviations from the protocol.

(2) Identification of sample material alloy(s), product temper, and selection of thickness of material tested including reference to product specification.

(3) Specimen details; type and dimensions of test specimen, and number of replicates.

(4) Identification of solution tested, concentration used and diluent used.

(5) Test conditions; temperature, exposure time, and humidity.

(6) Identification of testing laboratory and responsible technical point of contact.

(7) Individual and average test results.

(8) Results of visual inspections, observations, and discussion of specimen condition.

(9) Photographic documentation of specimen conditions (specifically any staining, evidence of general corrosion, etching, pitting, or localized attack).

#### **1.1.10 Steel Corrosion**

##### **Objective**

The objective of this test is to assess the relative degree of corrosivity of the manufacturer's suggested working concentration of the cleaning compound.

## Criterion

The manufacturer's suggested working concentration of the cleaning compound shall not cause any steel corrosion. If lightly rubbing the specimens with 00 steel wool does not remove any light stains or cleaner residue, the specimen is considered corroded.

## Test Procedures

The steel corrosion characteristics of the manufacturer's suggested working concentration of the cleaning compound are determined using ASTM D-130-94 (2000) modified (app B, ref 1.1-24) Standard Test Method for Detection of Copper Corrosion from Petroleum Products by the Copper Strip Tarnish Test.

a. Three specimens shall be examined for each of the test conditions detailed below. One strip shall remain unexposed to be used as a control specimen for visual inspection. The specimens shall be strips 12.5 mm (1/2 in.) wide, 1.5 to 3.0 mm (1/16 to 1/8 in.) thick, cut 75 mm (3 in.) long from SAE standard steel 1018. The strips may be used repeatedly but should be discarded when the surfaces become deformed on handling.

b. All six surfaces of each specimen should be prepared using 00 steel wool to remove all surface blemishes. At all times when handling the test strips protect the strip from contact with fingers with an ashless filter paper. Upon completion of the surface preparation immerse the specimen in solvent until immediately before testing.

c. Immediately before testing remove the test strip from the wash solvent. Wipe vigorously with fresh cotton pads and handle strips only with stainless steel forceps. Clean all metal dust by rubbing vigorously with clean cotton pads until a fresh pad remains clean.

d. When the strip is clean, immediately immerse it in the test solution.

e. Thirty milliliters of the manufacturer's suggested working concentration of the cleaning compound is placed in each of two 25- by 150-mm test tubes.

f. Within 1 minute of completing final preparation of the test specimens, they are to be placed into the test tubes with the manufacturer's suggested working concentration of the cleaning compound. Stopper the test tube with a vented cork.

g. The test tubes should be placed into a water bath maintained at the manufacturer's recommended operating temperature for 3 hours and the contents of the test tube should be protected from strong light during the test.

h. After 3 hours  $\pm$  5 minutes in the bath, the test tubes are removed from the bath and the contents are emptied into a clean beaker.

i. Immediately remove the test specimens with stainless steel forceps and immersed in wash solvent, then removed and blotted dry.

j. The specimens are then lightly rubbed with 00 steel wool and inspected for evidence of pitting, corrosion, permanent discoloration of the surface or the formation of a layer of reaction products.

k. Repeat the complete procedure for the following additional conditions:

(1) Three hour exposure at 100 °C (212 °F).

(2) Twenty-four hours exposure at the manufacturer's recommended operating temperature.

(3) Twenty-four hours exposure at 100 °C (212 °F).

l. Report the following information for each test performed:

(1) Summary of test methods and any deviations from the protocol.

(2) Identification of sample material alloy(s), product temper, and selection of thickness of material tested including reference to product specification.

(3) Specimen details; type and dimensions of test specimen and number of replicates.

(4) Identification of solution tested, concentration used, and diluent used.

(5) Test conditions; temperature, exposure time, and humidity.

(6) Identification of testing laboratory and responsible technical point of contact.

(7) Individual and average test results.

(8) Results of visual inspections, observations, and discussion of specimen condition.

(9) Photographic documentation of specimen conditions (specifically any staining, evidence of general corrosion, etching, pitting, or localized attack).

#### **1.1.11 Bimetal Corrosion**

##### **Objective**

The objective of this test is to determine the bimetallic corrosion characteristics of the manufacturer's suggested working concentration of the cleaning compound.

##### **Criterion**

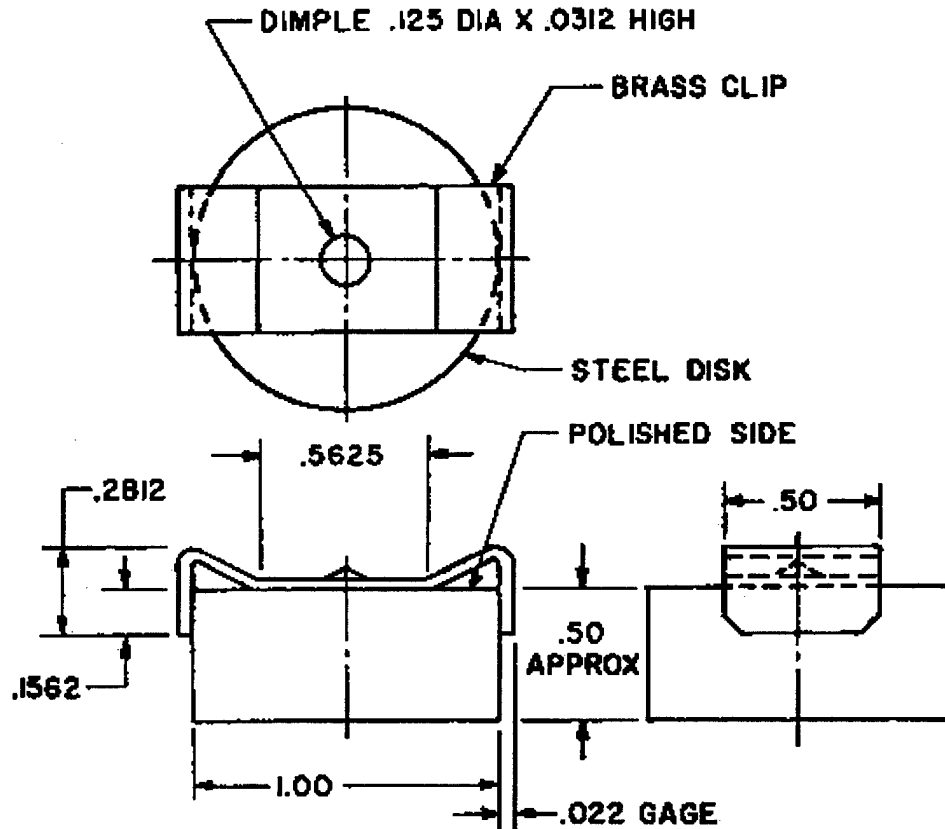
The manufacturer's suggested working concentration of the cleaning compound shall not cause corrosion on a bimetallic couple (Test Protocol). Any evidence of corrosion, pitting, or other attack in the test area constitutes a failure to meet this criterion.

## Test Procedures

The bimetallic couple corrosion characteristics of the manufacturer's suggested working concentration of the cleaning compound are determined using FED STD-791C Corrosiveness of Oil on a Bimetallic Couple, Test Method 5322.2 (app B, ref 1.1-25).

a. Prepare three disks each ASTM A-322, composition G52986, heat treated to Rockwell C-62, and aluminum 2024 T-3, 6061 T-6, and 7075 T-6, 2.54 cm (1 in.) diameter by 1.25 cm (1/2 in.) by 2.54 cm (1 in.) thick, ground on one side to 0.508 micrometer (20 microinch) root mean square (rms) prior to hand-polishing. This treatment need not be repeated prior to each test unless the disks are badly corroded.

b. Prepare three clips of brass (ASTM 1336/B36 M-95, Copper Alloy C26000) and three clips of 304 or 316 stainless steel for each type of aluminum tested, spring temper, fabricated to dimensions shown in Figure 1.1-1.



### NOTES:

1. DIMENSIONS IN INCHES.
2. TOLERANCE  $\pm .0312$ .

Figure 1.1-1. Drawing of bimetallic corrosion setup.



c. Prepare the disks as follows:

(1) Slush the disks in the methyl alcohol to remove traces of coolant used in grinding.

(2) Polish the surface-ground side using 150, 240, 400, and 600 grit silicon carbide or aluminum oxide paper in succession. Perform each polishing operation at right angles to the previous one, and continue until all cross scratches from the previous operation are removed.

(3) Clean the disks by wiping with the clean, dry, lint-free cloth, being careful not to touch the polished surface with bare hands.

(4) Examine with the 10X magnifier for discoloration, etching, pitting, or other signs of corrosion. Discard disks with any sign of corrosion.

(5) Store the disks in the desiccator until use. Immerse the clips in the etching solution for 20 seconds, and immediately wash successively in cold running water, distilled water, and acetone. Allow to air dry, and store in the desiccator until ready for use. Be careful not to touch (with bare hands) the surface that will be in contact with the disks.

d. Remove the disks from the desiccator (being careful not to touch the finished surface), and using a stirring rod, drip the test cleaner over the entire polished surface of each disk.

e. Remove the brass clips from the desiccator (being careful not to touch the area to be in contact with the polished surface of the disks), and place on the disks as indicated in Figure 1.1-2 so that the center of the clip is in full contact with the disk.

f. Place the assemblies in the humidity cabinet for 10 days (relative humidity,  $0 \pm 5$  percent; temperature  $27^\circ \pm 2^\circ \text{C}$  ( $79^\circ \text{F}$ )).

g. Remove the assemblies from the cabinet after 10 days, and using a sharp pencil, mark an outline of the clips where they were in contact with the polished surface of the disks. Remove the clips, and wipe the disks clean with a lint free cloth.

h. Using the 10X magnifier, examine the marked-off area of the disks for discoloration, etching, pitting, or other signs of corrosion.

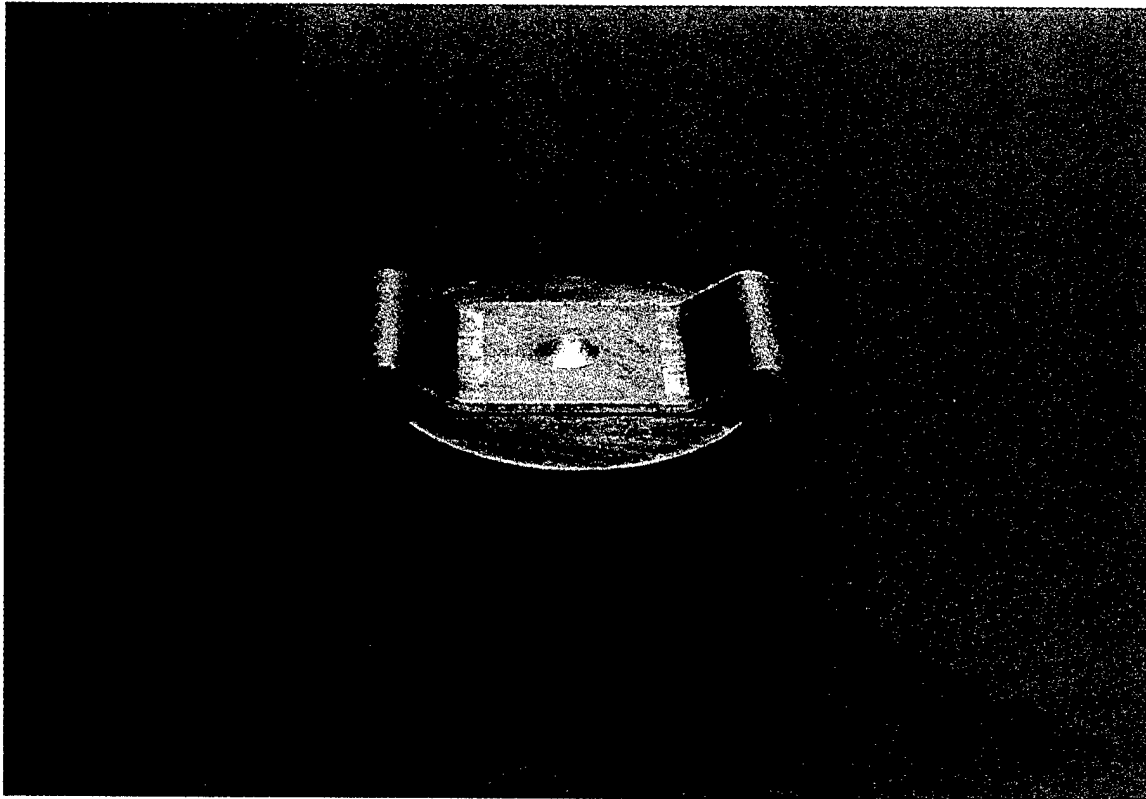


Figure 1.1-2. Bimetal couple corrosion test specimen pair.

- i. Report the following information for each test performed:
  - (1) Summary of test methods and any deviations from the protocol.
  - (2) Identification of sample material alloy(s), product temper, and selection of thickness of material tested including reference to product specification.
  - (3) Specimen details; type and dimensions of test specimen and number of replicates.
  - (4) Identification of solution tested, concentration used, and diluent used.
  - (5) Test conditions; temperature, exposure time, and humidity.
  - (6) Identification of testing laboratory and responsible technical point of contact.
  - (7) Individual and average test results.
  - (8) Results of visual inspections, observations, and discussion of specimen condition.
  - (9) Photographic documentation of specimen conditions (specifically any staining, evidence of general corrosion, etching, pitting, or localized attack).

## 1.2 EFFECTS ON PAINTED SURFACES

### Objective

The objective of this test is to determine the effects on painted surfaces of the manufacturer's suggested working concentration of the cleaning compound.

### Criterion

The manufacturer's suggested working concentration of the cleaning compound shall not cause streaking, discoloration, blistering or a permanent decrease in film hardness of more than one (1) pencil hardness level on any painted surfaces.

### Test Procedures

The effect of the manufacturer's suggested working concentration of the cleaning compound on the painted surfaces is determined using ASTM F-502-93 (1998) (app B, ref 1.2-2), Standard Test Method for Effects of Cleaning and Chemical Maintenance Materials on Painted Aircraft Surfaces, modified by the Test Protocol.

a. The 12 test panels of aluminum Alclad 7075-T6, 76 by 152 by 0.5 mm (3 by 6 by 0.02 in.) are prepared according to the procedure given in ASTM F-502.

b. All of the test panels are cleaned with acetone, dried, and abraded lightly with a fine aluminum oxide mat. The surface is then rinsed with distilled water.

c. All of the test panels are coated with a conversion coat conforming to MIL-C-81706, Class 1A (app B, ref 1.2-3), and allowed to dry.

d. One coat of MIL-P-23377 (Type I, Class C) (app B, ref 1.2-4) epoxy primer, 0.6 to 0.8 mil (0.010 to 0.015 mm) is applied to the test panels.

e. The test panels are allowed to dry for 1 hour at ambient (room) conditions.

f. Each of the following coatings is to be applied to three test panels: (Aircraft green is the preferred color.)

(1) MIL-C-22750 (app B, ref 1.2-5) epoxy topcoat.

(2) MIL-C-85285, Type I (app B, ref 1.2-6) polyurethane, high-solids topcoat.

(3) MIL-C-46168, Type IV (app B, ref 1.2-7) aliphatic polyurethane, single-component topcoat.

(4) MIL-P-14105 (app B, ref 1.2-8) heat-resistant paint.

g. The coatings in paragraph f are to be applied as a mist coat and allowed to dry for 30 minutes in ambient (room) conditions.

h. An additional three coats of the coatings should be applied in 0.010- to 0.015-mm applications and allowed a 1-hour drying time at ambient (room) conditions between each coat.

i. The test panels are allowed to dry for four days at ambient (room) conditions.

j. The test panels are then baked for 24 hours in a mechanical convection oven at 82 °C (180 °F) or allowed to air dry an additional 3 to 10 days at room temperature.

k. A set of drawing pencils is prepared as described in the Test Plan.

(1) Strip the wood away from one end of each pencil approximately 3/8 inch without damaging the lead.

(2) Square the tip of the lead by holding the pencil in a vertical position and moving the lead back and forth over a very fine (180 to 320 grit) sandpaper.

(3) Square the tip of the lead after each trial.

l. Place the test panels in a horizontal position in an oven maintained at  $38 \pm 2$  °C ( $100 \pm 5$  °F).

m. Apply the test solution to approximately one half the area of each panel and allow to remain on the panels for 30 minutes.

n. Then remove the panels from the oven and rinse with distilled or deionized water and allow to air dry for 24 hours.

o. Examine for streaking, discoloration, or blistering of the finish.

p. Determine the hardness of the treated and untreated areas in the following manner:

(1) Hold pencils of decreasing hardness in a mechanical holder that maintains the pencil at 45° with approximately 300 g of pressure at the pencil point. Push across the paint film with a constant speed until a pencil is found that will not cut the film but will leave a black mark on the surface, whereas the next hardest pencil will cut through the film without leaving a black mark.

(2) The hardness number of the pencil that cuts the film shall express film hardness.

(3) Make at least three determinations on both exposed and unexposed portions of the coated panel.

q. Perform procedure for each of three panels for each coating set.

r. The paint hardness is not allowed to differ by more than one pencil hardness unit for each of the same type of paint test panels.

s. Report the following information for each test performed:

(1) Summary of test methods and any deviations from the protocol.

(2) Identification of sample material alloy(s), product temper, and selection of thickness of material tested including reference to product specification.

(3) Specimen details; type and dimensions of test specimen and number of replicates.

(4) Identification of solution tested, concentration used, and diluent used.

(5) Test conditions; temperature, exposure time and humidity.

(6) Identification of testing laboratory and responsible technical point of contact.

(7) Individual and average test results.

(8) Results of visual inspections, observations, and discussion of specimen condition.

(9) Photographic documentation of specimen conditions (specifically any staining, evidence of general corrosion, etching, pitting, or localized attack).

## **1.3 PLASTICS/SEALANTS**

### **1.3.1 Effects On Coated Wire And Heat Shrink Tubing**

#### **Objective**

The objective of this test is to determine the effects on coated wire and heat shrink tubing of the manufacturer's suggested working concentration of the cleaning compound.

#### **Criterion**

The manufacturer's suggested working concentration of the cleaning compound shall not cause cracking, discoloration, dissolution of the tubing and wire coating, dielectric breakdown of the insulated wire in excess of that produced by distilled water (Test Protocol).

#### **Test Procedures**

The effect that the manufacturer's suggested working concentration of the cleaning compound has on the samples is determined using ASTM D6361-98, Standard Guide for Selecting Cleaning Agents and Processes, Appendix XI (app B, ref 1.1-22).

a. Two lengths of approximately 61 cm (24 in.) of MIL-W-81381/11-20 wire are cut from each of the following materials:

- (1) Teflon coated wire.
- (2) Polymide coated wire.
- (3) Silicon coated wire.
- (4) Polyolefin coated wire.

b. Heat shrink tubing is applied over the type of wire specified and in the manner directed by the tubing manufacture. The tubing does not need to be applied over a joint or splice in the wire.

c. Each segment of wire is then coiled tightly around a 0.3 cm (0.125 in.) diameter bar and placed into separate 118-mL (4-oz) widemouth jars. The heat shrink tubing coated wire is coiled around the same diameter bar or as tightly as possible.

d. Enough of the manufacturer's maximum suggested working concentration of the cleaning compound is added to one jar of each segment type to completely cover the wire coil.

e. Enough deionized water (ASTM D-1193, Type IV (app B, ref 1.1-10)) is added to the other jar (control sample) to completely cover the wire coil.

f. All jars are capped and stored at room temperature (20 to 25 °C) for 14 days.

g. After 14 days, all coils are removed and rinsed thoroughly with distilled water.

h. All coils are then suspended and allowed to dry completely.

i. When dry, the wires are uncoiled and examined for dissolution.

j. All coils are then double-reverse wrapped on a 0.3-cm (0.125-in.) mandrel and observed for cracking under a 10 power lens.

k. If the test wire cracks, the test is ended. If the control wire cracks, the test is invalidated and must be rerun.

l. The wires are then subjected to a 1-minute dielectric test of 2500 volts (rms), using a Hypot model No. 4045, or equivalent and examined.

m. The wires are then examined for breakdown and/or leakage. All wires should be photographically documented immediately upon completion of the test. Wires immersed in the cleaner shall perform equally well as the control wire immersed in distilled water.

n. Report the following information for each test performed:

(1) Summary of test methods and any deviations from the protocol.

(2) Identification of sample material alloy(s), product temper, and selection of thickness of material tested including reference to product specification.

(3) Specimen details; type and dimensions of test specimen and number of replicates.

(4) Identification of solution tested, concentration used, and diluent used.

(5) Test conditions; temperature, exposure time, and humidity.

(6) Identification of testing laboratory and responsible technical point of contact.

(7) Individual and average test results.

(8) Results of visual inspections, observations, and discussion of specimen condition.

(9) Photographic documentation of specimen conditions (specifically any staining, evidence of general corrosion, etching, pitting, or localized attack).

### **1.3.2 Effects On Acrylic Plastics**

#### **Objective**

The objective of this test is to determine the effects on acrylic plastic of the manufacturer's suggested working concentration of the cleaning compound.

#### **Criterion**

The manufacturer's suggested working concentration of the cleaning compound shall not cause stress crazing or staining of acrylic plastics (Test Protocol).

#### **Test Procedures**

The stress-crazing effect that the manufacturer's suggested working concentration of the cleaning compound has on acrylic plastics is determined using ASTM F-484-83 (1998) (app B, ref 1.3-1), Standard Test Method for Stress Crazing of Acrylic Plastics in Contact with Liquid or Semi-Liquid Compounds.

a. Four specimens, two control and two test, are prepared for each of the following materials:

- (1) Type A - MIL-P-5425, finish A (app B, ref 1.3-2).
- (2) Type B - MIL-P-8184, finish B (app B, ref 1.3-3).
- (3) Type C - MIL-P-25690B (app B, ref 1.3-4).

b. The specimens are prepared and conditioned as follows:

(1) The test specimens shall be machined from  $6.4 \pm 0.64$  mm ( $0.25 \pm 0.025$  in.) thick polished acrylic plastic sheet conforming to the applicable specification.

(2) The test specimens shall be  $25.4 \pm 0.8$  mm ( $1 \pm 0.003$  in.) wide by  $177.8 \pm 1.27$  mm ( $7 \pm 0.05$  in.) long by  $6.4 \pm 0.64$  mm ( $0.25 \pm 0.025$  in.) thick. Edges shall be a smooth machined surface without cracks.

(3) Do not anneal Type C acrylic specimens.

(4) Anneal Type A and Type B acrylic test specimens after machining by heating in a circulating air oven at  $91 \pm 3$  °C ( $195 \pm 5$  °F) for 5-1/2 hours. Cool the specimens to room temperature in the oven using a uniform cooling rate of 28 °C (50 °F) per hour.



(5) Condition all specimens at  $23 \pm 5^\circ\text{C}$  ( $75 \pm 10^\circ\text{F}$ ) and percent relative humidity for a minimum of 24 hours just before testing.

c. Testing is conducted at  $23 \pm 5^\circ\text{C}$ .

d. Each test specimen is loaded as a cantilever beam as shown in Figure 1.3-1. The following recommended stress levels are to be applied:

(1) Type A - 20,685 kPa (3,000 psi) outer fiber stress.

(2) Type B - 24,132 kPa (3,500 psi) outer fiber stress.

(3) Type C - 31,027 kPa (4,500 psi) outer fiber stress.

e. The test specimens are stressed for 10 minutes.

f. The test specimens are examined for crazing under the lighting and visual inspection conditions prescribed in ASTM F-484-83, Figure 1.3.2-1.

g. If no crazing occurs, testing proceeds. If crazing occurs, a new test specimen is used and the loading test is repeated.

h. The test specimen is loaded again to the proper load.

i. An absorbent cotton swatch, 12.7 mm (0.5 in.) square, is placed directly over the fulcrum on the tension surface in the middle of the test specimen's width so that there is a clear space along the edge to avoid initiating crazing of the edge.

j. The cotton swatch is completely soaked with the manufacturer's suggested working concentration of the cleaning compound. Keep the swatch moist with the test compound for the duration of the test.

k. At no time is the manufacturer's suggested working concentration of the cleaning compound allowed to migrate to within 3.2 mm (0.125 in.) of the edge of the test specimen.

l. The test duration shall be 8 hours. After test compound exposures of 30 minutes, 1, 2, 4, and 8 hours, inspect the specimens for crazing or degradation. Do this by sliding the moist swatch approximately 2 in. toward the loaded end. Carefully wipe the test area clean. A clean cloth, wet with distilled or deionized water conforming to Specification ASTM D-1193, Type IV (app B, ref 1.1-10) may be used to remove dry residue if necessary in the cleaning operation.

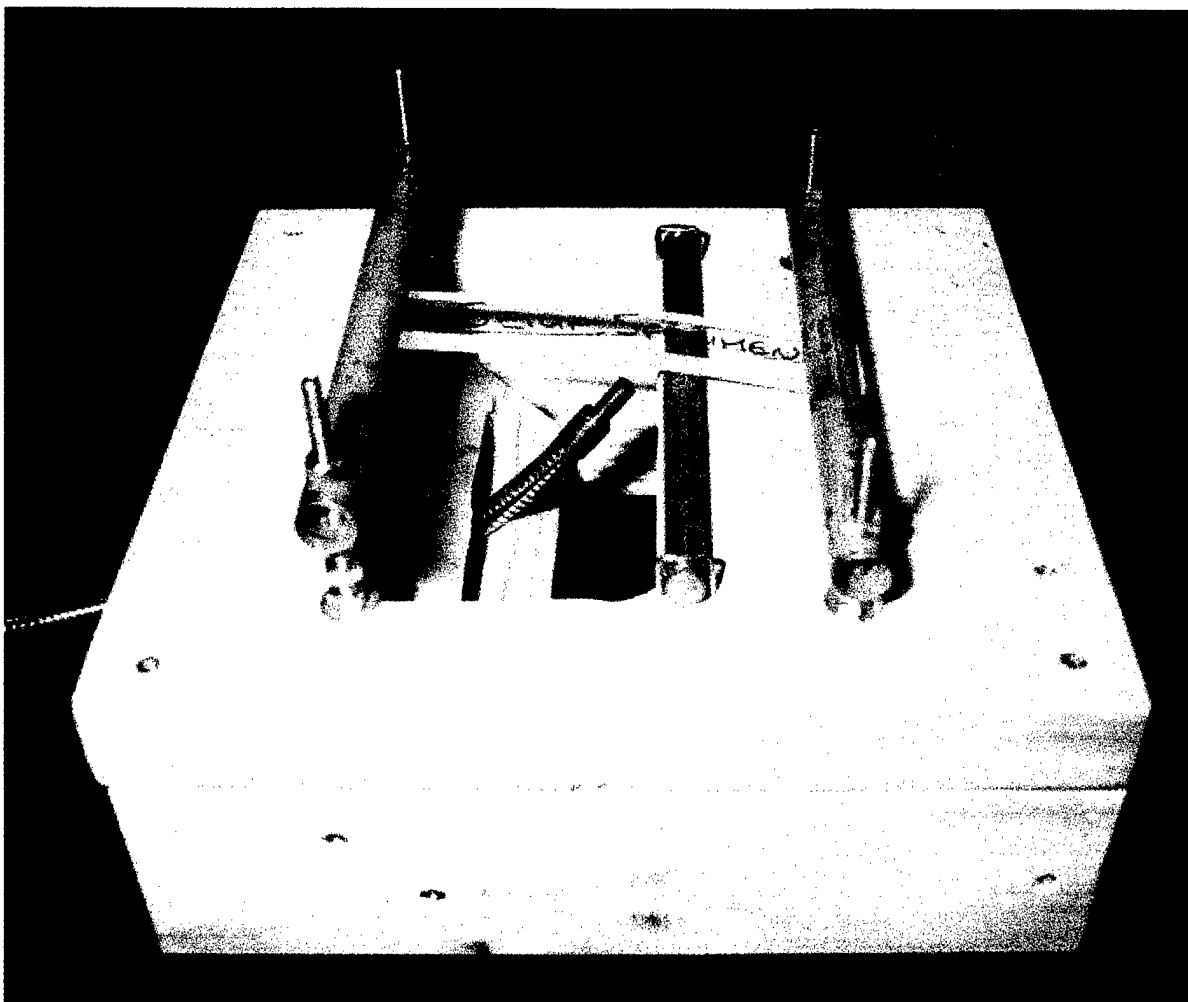


Figure 1.3-1. Plastic loading test fixture.

m. Carefully examine the top (tension) surface of the specimen in the manner shown in Figure 1.3-1 for any evidence of crazing, cracks, or etching effect on the polished surface of the acrylic test specimen.

n. Use a single point source of concentrated colimated light, such as a large-size microscope illuminator, for inspection.

o. Disregard crazing that initiates at the edge of the specimen unless it grows and extends across the specimen. In this case, the time of the meeting of the crazing from the edges shall be taken as the end point of the test. Terminate the test as soon as crazing or degradation is observed, even though the full 8 hours duration has not been reached.

p. After each examination at the specified intervals during the 8-hour period, move the moist swatch back to its original position over the stress area and remoisten it with test compound as required.

q. Testing is terminated at any point when crazing or degradation is observed.

r. The steps in paragraph d through q are repeated for both samples of each type of acrylic.

s. The steps in paragraphs d through r, are repeated for each plastic control pair with the substitution of distilled water conforming to Specification ASTM D-1193, Type IV, for the manufacturer's suggested working concentration of the cleaning compound in paragraph j. All test specimens should be photographically documented immediately upon completion of the test.

t. Report the following information for each test performed:

(1) Summary of test methods and any deviations from the protocol.

(2) Identification of sample material alloy(s), product temper, and selection of thickness of material tested including reference to product specification.

(3) Specimen details; type and dimensions of test specimen and number of replicates.

(4) Identification of solution tested, concentration used, and diluent used.

(5) Test conditions; temperature, exposure time, and humidity.

(6) Identification of testing laboratory and responsible technical point of contact.

(7) Individual and average test results.

(8) Results of visual inspections, observations, and discussion of specimen condition.

(9) Photographic documentation of specimen conditions (specifically any staining, evidence of general corrosion, etching, pitting, or localized attack).

### **1.3.3 Effects On Polycarbonate Plastics**

#### **Objective**

The objective of this test is to determine the effects on polycarbonate plastic of the manufacturer's suggested working concentration of the cleaning compound.

## Criterion

The manufacturer's suggested working concentration of the cleaning compound shall not cause stress crazing or staining of polycarbonate plastics (Test Protocol).

## Test Procedures

The stress-crazing effect that the manufacturer's suggested working concentration of the cleaning compound has on polycarbonate plastics is determined using ASTM F-484-83 (1998) modified, Standard Test Method for Stress Crazing of Acrylic Plastics in Contact with Liquid or Semi-Liquid Compounds (app B, ref 1.3-1).

a. Four specimens, two control and two test, should be prepared and conditioned in accordance with ASTM F-484-83 (1998), paragraphs 5 and 6, using polycarbonate plastic conforming to MIL-P-83310 (app B, ref 1.3-5).

b. Testing is conducted at  $23 \pm 5$  °C ( $75 \pm 10$  °F).

c. Each test specimen is loaded as a cantilever beam.

d. An outer fiber stress of 13,790 kPa (2,000 psi) is applied.

e. The test specimen is stressed for 10 minutes at the above load.

f. The test specimen is then examined for crazing under the lighting and visual inspection conditions prescribed in ASTM F-484-83.

g. If no crazing occurs, the test should proceed. If crazing occurs, then a new test specimen should be made and the preceeding steps are repeated.

h. The test specimen is again loaded to the stated load.

i. An absorbent cotton swatch, 12.7 mm (0.5 in.) square, is placed directly over the fulcrum on the tension surface in the middle of the test specimen's width so that there is a clear space along the edge to avoid initiating crazing of the edge.

j. The swatch is then completely soaked with the manufacturer's suggested working concentration of the cleaning compound. Keep the swatch moist with the test compound for the duration of the test.

k. The manufacturer's suggested working concentration of the cleaning compound is not allowed to migrate to within 3.2 mm (0.125 in.) of the edge of the test specimen.

l. The test specimen is then inspected for crazing as in paragraph f, after loading  $30 \pm 2$  minutes. Inspection is conducted by sliding the swatch 5.08 cm (2 in.) towards the loaded end of the test specimen.

m. Carefully examine the top (tension) surface of the specimen in the manner shown in Figure 1.3-1 for any evidence of crazing, cracks, or etching effect on the polished surface of the polycarbonate test specimen.

n. Use a single point source of concentrated colimated light, such as a large-size microscope illuminator, for inspection.

o. Disregard crazing that initiates at the edge of the specimen unless it grows and extends across the specimen.

p. The steps in paragraphs c through o are repeated with a second specimen. Two control specimens are then testing using distilled water conforming to ASTM D-1193, Type IV (app B, ref 1.1-10). All test specimens should be photographically documented immediately upon termination of the test.

q. Report the following information for each test performed:

(1) Summary of test methods and any deviations from the protocol.

(2) Identification of sample material alloy(s), product temper, and selection of thickness of material tested including reference to product specification.

(3) Specimen details; type and dimensions of test specimen and number of replicates.

(4) Identification of solution tested, concentration used, and diluent used.

(5) Test conditions; temperature, exposure time, and humidity.

(6) Identification of testing laboratory and responsible technical point of contact.

(7) Individual and average test results.

(8) Results of visual inspections, observations, and discussion of specimen condition.

(9) Photographic documentation of specimen conditions (specifically any staining, evidence of general corrosion, etching, pitting, or localized attack).

#### **1.3.4 Effects On Polysulfide Sealants**

##### **Objective**

The objective of this test is to determine the effect on polysulfide sealant of the manufacturer's suggested working concentration of the cleaning compound.

### Criterion

The manufacturer's suggested working concentration of the cleaning compound shall not change the durometer hardness of polysulfide sealants more than 5 units (Test Protocol).

### Test Procedures

The effect that the manufacturer's suggested working concentration of the cleaning compound has on polysulfide sealants is determined using ASTM D-6361-98, Standard Guide for Selecting Cleaning Agents and Processes, Appendix X3 (app B, ref 1.1-22).

- a. Two test specimens should be prepared from MIL-PRF-81733-D, Type II-2 (Class 1, Grade A (app B, ref 1.3-6), and AMS-S-8802, Class B-2 (app B, ref 1.3-7) sealants sheet stock.
- b. It is assumed that these materials do not have hardnesses that depend on humidity.
- c. The sheet stock is made by mixing the sealants as specified by the manufacturer and pressing each into a 0.3175-cm (0.125-in.) thick sheet mold (fig. 1.3-2).

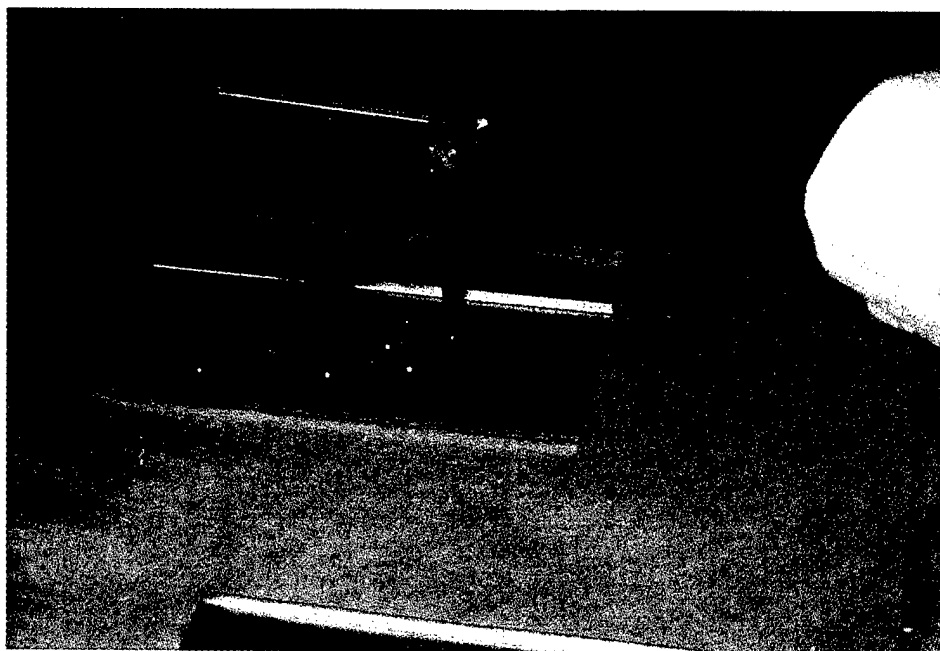


Figure 1.3-2. Sealant being formed in molds.

- d. The sealant is cured according to the manufacturer's specifications.
- e. Test specimens are cut from the cured sheet stock. Specimens should have sufficient surface area for hardness testing before and after exposure to the test cleaning compound. Recommended specimen dimensions would be 50 by 50 mm (2 by 2 in.).

f. Test each specimen for Shore A hardness in accordance with ASTM D-2240 (app B, ref 1.3-8). The measurement is an average of five readings.

g. All testing is conducted at ambient (room) temperature.

h. Immerse two test specimens from each sealant into the manufacturer's suggested working concentration of the cleaning compound.

i. The test specimens are allowed to soak for 30 minutes.

j. The test specimens are removed from the manufacturer's suggested working concentration of the cleaning compound and rinsed with cool tap water.

k. The test specimens are then tested for a Shore A hardness in accordance with ASTM D-2240-95 within 30 minutes of removal from the cleaning compound.

l. The cleaning compound shall not change the durometer hardness more than five units after exposure.

m. Report the following information for each test performed:

(1) Summary of test methods and any deviations from the protocol.

(2) Identification of sample material alloy(s), product temper, and selection of thickness of material tested including reference to product specification.

(3) Specimen details; type and dimensions of test specimen and number of replicates.

(4) Identification of solution tested, concentration used, and diluent used.

(5) Test conditions; temperature, exposure time, and humidity.

(6) Identification of testing laboratory and responsible technical point of contact.

(7) Individual and average test results.

(8) Results of visual inspections, observations, and discussion of specimen condition.

(9) Photographic documentation of specimen conditions (specifically any staining, evidence of general corrosion, etching, pitting, or localized attack).

### **1.3.5 Rubber Compatibility**

#### **1.3.5.1 Rubber Compatibility - Durometer Hardness**

##### **Objective**

The objective of this test is to evaluate the effect of the manufacturer's maximum recommended use concentration of the test cleaner on the durometer hardness of rubber compounds immersed in the cleaner.

##### **Criterion**

The manufacturer's suggested working concentration of the cleaning compound shall not change the durometer hardness of rubber materials more than 5 units (Test Protocol).

##### **Test Procedures**

Compatibility of the manufacturer's suggested working concentration of the cleaning compound with rubber compounds is determined using modified ASTM D-2240-95 (app B, ref 1.3-8), Standard Test Method for Rubber Property - Durometer Hardness.

- a. Three test specimens should be prepared from AMS 3204 (app B, ref 1.3-11) and AMS 3209 (app B, ref 1.3-12) rubbers in accordance with ASTM D-2240-95. In addition, three test specimens should also be prepared from high temperature fluid and compression set resistant fluorocarbon elastomer rubber (MIL-R-83248C (app B, ref 1.3-13)) in accordance with ASTM D-2240-95. Recommended specimen dimensions would be 2 by 2 inches (50 by 50 mm).
- b. It is assumed that these materials do not have hardnesses that depend on humidity.
- c. All testing is conducted at the manufacture's recommended operating temperature.
- d. Immerse two test specimens from each rubber into the manufacturer's suggested working concentration of the cleaning compound..
- e. The specimens are allowed to soak for the following exposure times: 30 minutes and 1, 2, 4, and 8 hours.
- f. After each of the exposure times, the specimens are removed, and durometer hardness is determined as outlined in ASTM Methods D-2240-95. The same test specimen should be used for all of the exposure times. The measurement at each exposure time is an average of five readings.
- g. The specimen is re-immersed after each hardness measurement.



h. Report the following information for each test performed:

- (1) Summary of test methods and any deviations from the protocol.
- (2) Identification of sample material alloy(s), product temper, and selection of thickness of material tested including reference to product specification.
- (3) Specimen details; type and dimensions of test specimen and number of replicates.
- (4) Identification of solution tested, concentration used, and diluent used.
- (5) Test conditions; temperature and exposure time.
- (6) Identification of testing laboratory and responsible technical point of contact.
- (7) Individual and average test results.
- (8) Results of visual inspections, observations, and discussion of specimen condition.
- (9) Photographic documentation of specimen conditions (specifically any staining, evidence of general or localized attack).

#### **1.3.5.2 Rubber Compatibility (Compression Set)**

##### **Objective**

The objective of this test is to measure the ability of rubber compounds to retain elastic properties after prolonged action of compressive stresses.

##### **Criterion**

The manufacturer's maximum recommended use concentration of the cleaning compound shall not cause a greater compression set than the compression set of the control sample tested in dry air.

##### **Test Procedures**

Compatibility of the manufacturer's maximum recommended use concentration of the cleaning solution is determined using ASTM D-395-98 (app B, ref 1.3-9). Standard Test Method for Rubber Property - Compression Set, Test Method B - Compression Set Under Constant Deflection in Air (modified). The ASTM D-395-98 is modified to change the exposure from air to the test cleaner solution.

a. Three test specimens and three control specimens should be prepared from each of the following rubbers, AMS 3204 (app B, ref 1.3-11), AMS 3209 (app B, ref 1.3-12), and high-temperature fluid and compression set resistant fluorocarbon elastomer rubber per MIL-R-83248C (app B, ref 1.3-13).

b. The standard test specimen shall be a cylindrical disk cut from a laboratory prepared slab.

c. The dimensions of the standard specimens shall be:

TYPE 2	
Thickness, mm (in.)	$6.0 \pm 0.2$ ( $0.24 \pm 0.01$ )
Diameter, mm (in.)	$13.0 \pm 0.2$ ( $0.51 \pm 0.01$ )

d. When cutting the standard specimen, the circular die having the required inside dimensions specified in paragraph c shall be rotated in a drill press or similar device and lubricated by means of a soap solution. A minimum distance of 13 mm (0.51 in.) shall be maintained between the cutting edge of the die and the edge of the slab. The cutting pressure shall be as light as possible to minimize cupping of the cut edges. The dies shall be maintained carefully so that the cutting edges are sharp and free of nicks.

e. It is important that all specimens be prepared in this manner so that the results may be compared. ASTM D-395, 5.5.4 states, "The results obtained on the specimens prepared by one of the methods may be compared only to those prepared by the same method."

f. Store all vulcanized test specimens or product samples to be tested at least 24 hours but not more than 60 days. When the date of vulcanization is not known, make tests within 60 days after delivery by the producer of the article represented by the specimen.

g. Allow buffed specimens to rest at least 30 minutes before specimens are cut for testing.

h. Condition all specimens before testing for a minimum of 3 hours at  $23 \pm 2$  °C ( $73.4 \pm 3.6$  °F). Specimens whose compression set properties are affected by atmosphere moisture shall be conditioned for a minimum of 24 hours in an atmosphere controlled to  $50 \pm 5$  percent humidity.

i. Measure the original thickness of the specimen to the nearest 0.02 mm (0.001 in.). Place the specimen on the anvil of the dial micrometer so that the presser foot will indicate the thickness at the central portion of the top and bottom faces.

j. Place the test specimen between the plates of the compression device with the spacers on each side, allowing sufficient clearance for the bulging of the rubber when compressed. Tighten the bolts so that the plates are drawn together uniformly until they are in contact with the spacers. The amount of compression employed shall be approximately 25 percent.

k. The test exposure of the rubber shall be conducted at the manufacturer's maximum recommended operating temperature for the cleaning solution. Each type of rubber shall be exposed in a separate container of the test cleaner at the manufacturer's recommended use concentration.

l. The test specimen shall be at room temperature when inserted in the compression device. Place the assembled compression device in the cleaner within 2 hours after completion of the assembly and allow it to remain there for the required test period of 22 hours at the test temperature selected. At the end of the test period, remove the test specimen from the device and allow them to cool.

m. While cooling, allow the test specimen to rest on a poor thermally conducting surface, such as wood, for 30 minutes before making the measurements of the final thickness. Conduct the cooling period at a standard laboratory temperature of  $23 \pm 2$  °C ( $73.4 \pm 3.6$  °F). Specimens whose compression set property is affected by atmospheric moisture shall be cooled in an atmosphere controlled to  $50 \pm 5$  percent relative humidity.

n. After the rest period, measure the final thickness at the center of the test specimen.

o. Calculate the compression set expressed as a percentage of the original deflection as follows:

$$C_B = [(t_o - t_i)/(t_o - t_a)] \times 100$$

where:

$C_B$  = Compression set expressed as percentage of the original deflection.

$t_o$  = Original thickness of specimen.

$t_i$  = Final thickness of specimen.

$t_a$  = Thickness of the spacer bar used.

p. Report the following information for each test performed:

(1) Summary of test methods and any deviations from the protocol.

(2) Identification of sample material alloy(s), product temper, and selection of thickness of material tested including reference to product specification.

(3) Specimen details; type and dimensions of test specimen and number of replicates.

- (4) Identification of solution tested, concentration used, and diluent used.
- (5) Test conditions; temperature, exposure time, and humidity.
- (6) Identification of testing laboratory and responsible technical point of contact.
- (7) Original dimensions of the test specimen including the original thickness.
- (8) Percentage compression of the specimen actually employed.
- (9) Thickness of the test specimen 30 minutes after removal from the clamp.
- (10) Type of test specimen used, together with the time and temperature of test.
- (11) Whether or not the surfaces of the compression device are lubricated. If they are, what type lubrication was used.
- (12) Compression set, expressed as a percentage of the original deflection.
- (13) Results of visual inspections, observations, and discussion of specimen condition.
- (14) Photographic documentation of specimen conditions (specifically any staining, evidence of general or localized attack).

#### **1.3.5.3 RUBBER COMPATIBILITY - CHANGE IN MASS, VOLUME AND DIMENSIONAL CHANGE**

##### **Objective**

The objective of this test is to evaluate the effect of the manufacturer's maximum recommended use concentration of the test cleaner on the mass, volume, and dimensions of rubber compounds immersed in the cleaner.

##### **Criterion**

The manufacturer's maximum recommended use concentration of the cleaning compound shall not change the mass, volume or dimensions of rubber materials.

##### **Test Procedures**

Compatibility of the manufacturer's maximum recommended use concentration of the cleaning solution with rubber is determined using ASTM D-471 (app B, ref 1.3-10), Standard Test Method for Rubber Property - Effect of Liquid, 10. Procedure for Change in Mass, 11. Procedure for Change in Volume, 12. Dimensional - Change Method.

a. Three test specimens should be prepared from each of the following rubbers, AMS 3204 (app C, ref 1.3-11), AMS 3209 (app B, ref 1.3-12), and high temperature fluid and compression set resistant fluorocarbon elastomer rubber per MIL-R-83248C (app C, ref 1.3-13).

b. The standard specimen shall be rectangular, having dimensions of 25 by 50 by  $2.0 \pm 0.1$  mm (1 by 2 by  $0.08 \pm 0.004$  in.).

c. Measure the original length and width of three test specimens to the nearest 0.5 mm (0.02 in.) using an average of three measurements in each direction recording the dimensions as  $L_o$  and  $W_o$  respectively. Measure the thickness of each test piece using a dial micrometer as described in 6.3 of Test Methods D-412 (app B, ref 1.3-14), and record as  $T_o$ . Obtain the mass  $M_1$  of each specimen in air, to the nearest 1 mg, and then obtain the mass  $M_2$  of each specimen immersed in distilled water at room temperature.

d. Place specimens in the immersion apparatus, a glass test tube, having an outside diameter of 38 mm (1.5 in.) and an overall length of 300 mm (12 in.) fitted loosely with a stopper shall be used.. (The stopper shall not contaminate the test liquid. When in doubt, cover the stopper with aluminum foil.) Glass beads shall be used in the liquid as a bumper and to separate the specimens. Fill the bottle with approximately 100 cm<sup>3</sup> of test liquid.

e. The test immersion shall be conducted in the test cleaner solution (maximum manufacturer's recommended concentration) at the manufacturer's maximum recommended operating temperature for a period of 168 hours. Condition the test tube assembly at the specified temperature for the specified length of time. The tolerance for any immersion period shall be  $\pm 15$  minutes. Immersion tests shall be made in the absence of direct light.

f. The apparatus and method chosen to maintain the specified temperature during immersion testing varies with test conditions, requirements, and circumstances. Water baths, appropriate temperature transfer oil baths, hot air oven, or aging blocks may be used. The apparatus must conform to ASTM D-471.

g. Test liquids shall not be reused.

h. At the end of the required immersion period, remove each specimen from the test tube. Cool the specimens to room temperature by transferring them to a cool, clean portion of the test liquid for 30 to 60 minutes, then dip quickly in acetone at room temperature, blot lightly with filter paper free of lint or foreign material, place in a tared, stoppered weighing bottle, weigh, and record the mass as  $M_3$ . Remove each specimen from the bottle, weigh in distilled water, and record the mass as  $M_4$  in immediate consecutive order to determine the water displacement after immersion.

i. Remeasure, recording the after immersion length, width, and thickness as  $L$ ,  $W$ , and  $T$ , respectively.

j. It is important that all air bubbles clinging to the test specimen be removed before weighing in distilled water. If, in the course of weighing, air bubbles appear on the surface of the specimen, or the computed volume changes 0.5 percent in 5 minutes, the specimen is too porous to permit volume determination in this manner. In that case, the initial volume of the specimen, if the latter is a simple geometrical solid, can be determined from the overall dimensions by employing an appropriate mensuration formula, and the same procedure followed in determining the volume after the immersion test; or, if volume increase occurs principally in the thickness dimension, a simple change in thickness may be substituted for change in volume. If, in the course of weighing, the test specimen floats, AISI No. 316 stainless steel can be used as ballast to immerse the test specimen in the test liquid. In those cases where ballast is needed to submerge the specimen, the following procedure may be used.

(1) Weigh the test specimen with ballast in water.

(2) Weigh the ballast alone in water.

(3) Determine the difference between the weighings, and proceed with the calculations.

(4) The acetone dip before and after immersion shall be omitted when water is employed as the test medium.

k. Calculate the percent change in mass as follows:

$$\Delta M, \% = \frac{(M_3 - M_1)}{M_1} 100$$

where:

$\Delta M$  = Change in mass, percent.

$M_1$  = Initial mass of specimen in air, g.

$M_3$  = Mass of specimen in air after immersion, g.

l. Calculate the percent change in volume as follows:

$$\Delta V, \% = \frac{(M_3 - M_4) - (M_1 - M_2)}{(M_1 - M_2)} 100$$

where:

$\Delta V$  = Change in volume, percent.

$M_1$  = Initial mass of specimen in air, g.

$M_2$  = Initial mass of specimen in water, g.

$M_3$  = Mass of specimen in air after immersion, g.

$M_4$  = Mass of specimen in water after immersion, g.

m. Calculate the percent change in dimensions as follows:

$$\Delta L, \% = \frac{(L - L_0)}{L_0} 100$$

where:

$\Delta L$  = Change in length, percent.

$L_0$  = Initial length of specimen.

$L$  = Length of specimen after immersion.

Calculate the percent change in width,  $\Delta W$ , and thickness,  $\Delta T$ , accordingly.

n. Report the following information for each test performed:

(1) Summary of test methods and any deviations from the protocol.

(2) Identification of sample material alloy(s), product temper, and selection of thickness of material tested including reference to product specification.

(3) Specimen details; type and dimensions of test specimen and number of replicates.

(4) Identification of solution tested, concentration used, and diluent used.

(5) Test conditions; temperature, exposure time, and humidity.

(6) Identification of testing laboratory and responsible technical point of contact.

(7) Individual and average test results.

(8) Results of visual inspections, observations, and discussion of specimen condition.

(9) Photographic documentation of specimen conditions (specifically any staining, evidence of general or localized attack).

#### **1.3.5.4 Rubber Compatibility - Mechanical Properties (Strength And Elongation)**

##### **Objective**

The objective of this test is to evaluate the effect of the manufacturer's maximum recommended use concentration of the test cleaner on the mechanical properties of strength, elongation and hardness of the rubber compounds immersed in the cleaner.

## Criterion

The manufacture's maximum recommended use concentration of the cleaning compound shall not increase or decrease the tensile strength, ultimate elongation or hardness of the rubber material.

## Test Procedures

Compatibility of the manufacturer's maximum recommended use concentration of the cleaning solution with rubber is determined using ASTM D-471 (app B, ref 1.3-10 ), Standard Test Method or Rubber Property - Effects of Liquids, 15, Changes in Tensile Strength, Elongation and Hardness, ASTM D-412 (app B, ref 1.3-14), Standard Test Method-Tension Testing, Rubber, Vulcanized and Thermoplastic Elastomers.

- a. Three test specimens and three control specimens should be prepared from each of the following rubbers, AMS 3204 (app B, ref 1.3-11), AMS 3209 (app B, ref 1.3-12), and high temperature fluid and compression set resistant fluorocarbon elastomer rubber per MIL-R-83248C (app B, ref 1.3-13).
- b. Prepare the specimens from flat vulcanized sheets  $2.0 \pm 0.1$  mm ( $0.08 \pm 0.004$  in.) in thickness using Die C of ASTM D-412 (app B, ref 1.3-14).
- c. The baseline tensile strength, ultimate elongation (ASTM D-412, Die C) and hardness (ASTM D-2240-95 (app B, ref 1.3-8)) shall be determined, using the three control specimens cut from the sheet adjacent to those that are to be immersed in the liquid.
- d. Measure the thickness of each test specimen.
- e. Place the specimens in the test tube; a glass test tube, having an outside diameter of 38 mm (1.5 in.) and an overall length of 300 mm (12 in.) fitted loosely with a stopper (The stopper shall not contaminate the test liquid. When in doubt, cover the stopper with aluminum foil.) shall be used. Glass beads shall be used in the liquid as a bumper and to separate the specimens.
- f. Add  $150 \text{ cm}^3$  of liquid to the test tube.
- g. Test liquids shall not be reused.
- h. The test immersion shall be conducted in the test cleaner solution (maximum manufacturer's recommended concentration) at the manufacturer's maximum recommended operating temperature for a period of 168 hours. Condition the test tube assembly at the specified temperature for the specified length of time. The tolerance for any immersion period shall be  $\pm 15$  minutes. Immersion tests shall be made in the absence of direct light.



i. At the end of the required immersion period, remove the specimens from the test tubes and cool immediately to room temperature in a fresh sample of the same liquid for 30 to 60 minutes. Then quickly dip each sample in acetone and blot lightly with filter paper that is free of lint and foreign material and immediately apply benchmarks.

j. The time interval between removal from the cool liquid and testing shall not be less than 2 nor more than 3 minutes.

k. Determine the tensile strength and ultimate elongation in accordance with ASTM D-412, using the original unimmersed thickness or cross-sectional area.

l. Determine the hardness of each immersed specimen in accordance with ASTM D-2240. The time interval between removal from the cool liquid and testing shall not be less than 2 nor more than 3 minutes.

m. Calculate the change in properties as follows:

(1) Tensile strength based on the original unstretched cross-sectional area:

$$TS_0 = \frac{F}{A}$$

(2) To express tensile strength and ultimate elongation after immersion as a percentage change from the original properties, use the following formula:

$$\Delta P, \% = \frac{P_i - P_o}{P_o} 100$$

(3) Calculate the hardness change after immersion in hardness units:

$$\Delta H = H_i - H_o$$

where:

$TS_0$  = Tensile stress based on original cross-sectional area.

$F$  = Observed force.

$A$  = Original cross-sectional area of the test specimen before immersion.

$\Delta P$  = Change in property (tensile strength and ultimate elongation) after immersion, %.

$P_o$  = Original property before immersion.

$P_i$  = Property after immersion.

$\Delta H$  = Hardness change after immersion.

$H_o$  = Original hardness before immersion.

$H_i$  = Hardness after immersion.

n. Report the following information for each test performed:

- (1) Summary of test methods and any deviations from the protocol.
- (2) Identification of sample material alloy(s) and selection of thickness of material tested including reference to product specification.
- (3) Specimen details; type and dimensions of test specimen and number of replicates.
- (4) Identification of solution tested, concentration used, and diluent used.
- (5) Test conditions; temperature, exposure time, and humidity.
- (6) Identification of testing laboratory and responsible technical point of contact.
- (7) Individual and average test results.
- (8) Results of visual inspections, observations, and discussion of specimen condition.
- (9) Photographic documentation of specimen conditions (specifically any staining, evidence of general or localized attack).

### **1.3.6 Effects On Unplasticized Polychlorotrifluoroethylene**

#### **1.3.6.1 Effects On Unplasticized Polychlorotrifluoroethylene (PCTFE) - Tensile Strength And Elongation**

##### **Objective**

The objective of this test is to determine the effects on the tensile strength and elongation of PCTFE of the manufacturer's suggested working concentration of the cleaning compound.

##### **Criterion**

The manufacturer's maximum recommended use concentration of the cleaning solution shall not cause the tensile strength or elongation of the PCTFE to fail to meet the minimum requirements of AMS 3650 (app B, ref 1.3-15). The minimum average tensile strength at  $23 \pm 1$  °C ( $73 \pm 2$  °F) shall not be less than 4500 psi (31.0 MPa). The minimum average percent elongation at  $23 \pm 1$  °C ( $73 \pm 2$  °F) shall not be less than 100%.

##### **Test Procedures**

Compatibility of the manufacturer's maximum recommended use concentration of the test cleaning solution is determined using ASTM D-638 (app B, ref 1.3-16), Standard Test Method for Tensile Properties and Plastics, modified to include exposure to the test cleaner solution.

a. Prepare five test specimens. The test specimens shall conform to the dimensions shown in Figure 1 of ASTM D-638 (app B, ref 1.3-16), Type I specimen with a thickness of 0.25 inch.

b. Measure the width and thickness of rigid flat specimens with a suitable micrometer to the nearest 0.025 mm (0.001 in.) at several points along their narrow sections.

c. Test specimens shall be immersed in the manufacturer's maximum recommended use concentration of the test cleaning solution at the maximum suggested operating temperature for a period of 8 hours.

d. Conduct tests in the Standard Laboratory Atmosphere of  $23 \pm 2$  °C ( $73.4 \pm 3.6$  °F) and  $50 \pm 5$  percent relative humidity.

e. Place the specimen in the grips of the testing machine, taking care to align the long axis of the specimen and the grips with an imaginary line joining the points of attachment of the grips to the machine. The distance between the ends of the gripping surfaces shall be 115 mm (4.5 in.). Tighten the grips evenly and firmly to the degree necessary to prevent slippage of the specimen during the test, but not to the point where the specimen would be crushed.

f. Attach the extension indicator if necessary.

g. Conduct the tensile test according to ASTM D-638 at a cross head speed of 1.0 inch (25 mm) per minute.

h. Record the load-extension curve of the specimen.

i. Discard the specimens that break at some obvious fortuitous flaw, or that do not break between the predetermined gage marks, and make retests.

j. Calculate and record the tensile strength and the percent elongation.

k. Report the following information for each test performed:

(1) Summary of test methods and any deviations from the protocol.

(2) Identification of sample material alloy(s), product temper, and selection of thickness of material tested including reference to product specification.

(3) Specimen details; type and dimensions of test specimen and number of replicates.

(4) Identification of solution tested, concentration used, and diluent used.

(5) Test conditions; temperature, exposure time, and humidity.

(6) Identification of testing laboratory and responsible technical point of contact.

(7) Individual and average test results.

(8) Results of visual inspections, observations, and discussion of specimen condition.

(9) Photographic documentation of specimen conditions (specifically any staining, evidence of general or localized attack).

### **1.3.6.2 Effects On Unplasticized Polychlorotrifluoroethylene (PCTFE) - Impact Strength**

#### **Objective**

The objective of this test is to determine the effects on the impact strength of PCTFE of the manufacturer's suggested working concentration of the cleaning compound.

#### **Criterion**

The manufacturer's maximum recommended use concentration of the cleaning solution shall not cause the impact strength of the PCTFE to fail to meet the minimum requirements of AMS 3650 Rev C (app B, ref 1.3-15). The minimum impact strength at  $23 \pm 1^\circ\text{C}$  ( $73 \pm 2^\circ\text{F}$ ) shall not be less than 1.25 foot pounds (66.75 J/m)/inch of notch width.

#### **Test Procedures**

Compatibility of the manufacturer's maximum recommended use concentration of the test cleaning solution is determined using ASTM D-256 (app B, ref 1.3-17), Standard Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics, Method A.

a. The test machine shall conform to all of the requirements stated in paragraph 6 of ASTM D-256.

b. Prepare ten test specimens and ten control specimens.

c. The test specimens shall conform to the dimensions and geometry of Figure 5, ASTM D-256. The specimens shall be cut from the sheet in both the lengthwise and crosswise directions unless otherwise specified. The width of the specimen shall be the thickness of the sheet, 127 mm (0.500 in.). Specimens may be tested either edgewise or flatwise as cut from the sheet. When specimens are tested flatwise, the notch shall be made on the machined surface if the specimen is machined on one face only. Each ten test and control specimens shall consist of five cut in the X-axis and five cut in the Y-axis.

d. The notching of the test specimens shall be done in accordance with paragraph 8 of ASTM D-256.

e. Condition the test specimens by immersing completely in the manufacturer's recommended use concentration of the test cleaning solution at the maximum suggested operating temperature for a period of 8 hours.

f. Condition the control specimens at  $23 \pm 2$  °C ( $73.4 \pm 3.6$  °F) and  $50 \pm 5$  percent relative humidity for not less than 40 hours after notching and prior to testing.

g. Conduct tests in the standard laboratory atmosphere of  $23 \pm 2$  °C ( $73.4 \pm 3.6$  °F) and  $50 \pm 5$  percent relative humidity.

h. Ten individual determinations of impact resistance must be made. Each group shall consist of specimens with the same nominal width ( $\pm 0.13$  mm ( $\pm 0.005$  in.)).

i. Use the lightest standard pendulum that is expected to break each specimen in the group with a loss of not more than 85 percent of its energy. Check the machine with the proper pendulum in place for conformity with the requirements of ASTM D-256 before starting the tests.

j. Verify the proper operation of the test instrument and determine the instrument's friction reading as stated in ASTM D-256, app B, ref 1.3-20.

k. Check the specimens for conformity with the requirements. Measure the width and depth to the nearest 0.025 mm (0.001 in.) after notching of each specimen. Measure the width in the region of the notch.

l. Position the specimen precisely so that it is rigidly, but not too tightly clamped in the vise. Pay special attention to ensure that the impacted end of the specimen is the end projecting above the vise. Release the pendulum and record the excess energy remaining in the pendulum after breaking the specimen.

m. Examine the test specimens and record the description of the appearance of the broken specimen according to the failure categories below:

(1) C - Complete Break. A break where the specimen separates into two or more pieces.

(2) H - Hinge Break. An incomplete break, such that one part of the specimen cannot support itself above the horizontal when the other part is held vertically (less than 90° included angle).

(3) P - Partial Break. An incomplete break that does not meet the definitions for a hinge break but has fractured at least 90 percent of the distance between the vertex of the notch and the opposite side.

(4) NB - Nonbreak. An incomplete break where the fracture extends less than 90 percent of the distance between the vertex of the notch and the opposite side.

n. Calculate the average Izod impact resistance of the group specimens. Only values of specimens having the same nominal width and type of break may be averaged. Values obtained from specimens that did not break in the manner specified shall not be included in the average. Also calculate the standard deviation of the group of values.

o. Report the following information:

(1) Summary of test methods and any deviations from the protocol.

(2) Identification of material tested, including type source, manufacturer's code number, and previous history.

(3) Specimen details; how the specimens were prepared, the testing conditions used, the number of hours the specimens were conditioned after notching, and for sheet materials the direction of testing with respect to anisotropy, if any.

(4) The capacity of the pendulum in joules, or foot pound-force, or inch pound-force.

(5) The width and depth under the notch of each specimen tested

(6) The total number of specimens tested per sample of material

(7) The type of failure.

(8) The impact resistance must be reported in J/m (ft-lbf/in.); the optional units of  $\text{kJ/m}^2$  (ft-lbf/in.<sup>2</sup>) may also be required.

(9) The number of those specimens that resulted in failures which conforms to each of the requirement categories in paragraph m.

(10) The average impact resistance and standard deviation (in J/m (ft-lbf/in.)) for those specimens in each failure category, except nonbreak.

(11) The percent of specimens failing in each category suffixed by the corresponding letter code from paragraph m.

### **1.3.6.3 Effects On Unplasticized Polychlorotrifluoroethylene PCTFE) - Specific Gravity**

#### **Objective**

The objective of this test is to determine the effects on the specific gravity of PCTFE of the manufacturer's suggested working concentration of the cleaning compound.

## Criterion

The manufacturer's maximum recommended use concentration of the cleaning solution shall not cause the specific gravity of the PCTFE to fail to meet the minimum requirements of AMS 3650 (app B, ref 1.3-15). The specific gravity at 23/23 °C (73/73 °F) shall be in the range 2.08 - 2.18.

## Test Procedures

Compatibility of the manufacturer's maximum recommended use concentration of the test cleaning solution is determined using ASTM D-792-98 (app B, ref 1.3-18), Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.

- a. Prepare three test specimens and three control specimens. The test specimen shall be a single piece of the material under test of any size and shape. The test specimen shall be a 1/2- by 1/2-inch section of 1/2-inch sheet.
- b. Condition the test specimens by immersing completely in the manufacturer's maximum recommended use concentration of the test cleaning solution at the maximum suggested operating temperature for a period of 8 hours.
- c. Weigh the specimen in air to the nearest 0.1 mg for specimens of mass 1 to 10 g or to the nearest mg for specimens of mass 10 to 50 g.
- d. Attach to the balance a piece of fine wire sufficiently long enough to reach from the hook above the pan to the support for the immersion vessel. Attach the specimen to the wire such that it is suspended about 25 mm above the vessel support.
- e. Mount the immersion vessel on the support, and completely immerse the suspended specimen (and sinkers, if used) in water at a temperature of  $23 \pm 2$  °C. The vessel must not touch wire or specimen. Remove any bubbles adhering to the specimen, wire, or sinker, paying particular attention to holes in the specimen and sinker. Usually these bubbles can be removed by rubbing them with another wire. Determine the mass of the suspended specimen to the required precision. Record this apparent mass as *b*. Weigh rapidly in order to minimize absorption of water by the specimen.
- f. Weigh the wire (and sinker, if used) in water with immersion to the same depth as used in the previous step. Record this weight as *w* (mass of the wire in liquid)
- g. Repeat the procedure for the remaining test specimens and the control specimens.

h. Calculate the specific gravity of the plastics as follows:

$$\text{Sp gr } 23/23\text{ }^{\circ}\text{C} = a/(a + w - b)$$

where:

- $a$  = apparent mass of specimen, without wire or sinker, in air.
- $b$  = apparent mass of specimen ( and of sinker, if used) completely immersed and of the wire partially immersed in liquid.
- $w$  = apparent mass of totally immersed sinker (if used) and of partially immersed wire.

The specific gravity at 23/23 °C (73/73 °F) shall be in the range 2.08 to 2.18. If the specific gravity of the control specimens are out of the range the test is invalid.

i. Report the following information for each test performed:

- (1) Summary of test methods and any deviations from the protocol.
- (2) Identification of sample material alloy(s), product temper, and selection of thickness of material tested including reference to product specification.
- (3) Specimen details; type and dimensions of test specimen and number of replicates.
- (4) Identification of solution tested, concentration used, and diluent used.
- (5) Test conditions; temperature, exposure time, and humidity.
- (6) Identification of testing laboratory and responsible technical point of contact.
- (7) Individual and average test results.
- (8) Results of visual inspections, observations, and discussion of specimen condition.
- (9) Photographic documentation of specimen conditions (specifically any staining, evidence of general or localized attack).

#### **1.3.6.4 Effects On Unplasticized Polychlorotrifluoroethylene (PCTFE) - Dimensional**

##### **Objective**

The objective of this test is to determine the effects on the dimensional stability of PCTFE of the manufacturer's suggested working concentration of the cleaning compound.



## Criterion

The manufacturer's maximum recommended use concentration of the cleaning solution shall not cause the dimensional stability of the PCTFE to fail to meet the minimum requirements of AMS 3650 (app B, ref 1.3-15). No dimensions shall change more than 0.003 inch per inch (0.003 mm/mm) measured at 20° - 30 °C (68° - 86 °F) before and after exposure to the test cleaner solution.

## Test Procedures<sup>a</sup>

a. Measure the original length and width of the three specimens used in 1.3.7.3 Specific Gravity to the nearest 0.001 inch using an average of three measurements in each direction recording the dimensions as  $L_o$  and  $W_o$ , respectively.

b. Measure the thickness of each test piece using a dial micrometer and record as  $T_o$ .

c. Condition the test specimens by immersing completely in the manufacturer's maximum recommended use concentration of the test cleaning solution at the maximum suggested operating temperature for a period of 8 hours.

d. At the end of the immersion period remove the specimens from the test solution. Blot lightly with filter paper free of lint and foreign material, and promptly remeasure as described above, recording the after immersion length, width, and thickness as  $L$ ,  $W$ , and  $T$  respectively.

e. Report the following information for each test performed:

(1) Summary of test methods and any deviations from the protocol.

(2) Identification of sample material alloy(s), product temper, and selection of thickness of material tested including reference to product specification.

(3) Specimen details; type and dimensions of test specimen and number of replicates.

(4) Identification of solution tested, concentration used, and diluent used.

(5) Test conditions; temperature, exposure time, and humidity.

(6) Identification of testing laboratory and responsible technical point of contact.

(7) Individual and average test results.

(8) Results of visual inspections, observations, and discussion of specimen condition.

<sup>a</sup>Complete this procedure simultaneously with the Specific Gravity test 1.3.7.3, using the same specimens and measuring dimensions prior to weighing the specimens.

(9) Photographic documentation of specimen conditions (specifically any staining, evidence of general or localized attack).

### **1.3.7 Effects on Single Component Sealing, Locking, and Retaining Compounds**

#### **Objective**

The objective of this test is to determine the effects on thread locking compound resulting from exposure to the manufacturer's suggested working concentration of the cleaning compound.

#### **Criterion**

The manufacturer's suggested working concentration of the cleaning compound shall not reduce the locking torque of Grade C-Blue unpolymerized sealing compound as presented in Table 1, Section 1.2.1 of Military Specification MIL-S-22473E, Sealing, Locking, and Retaining Compounds: (Single-Component) (app B, ref 1.3-19).

#### **Test Procedures**

The effect that immersion in the manufacturer's suggested working concentration of the cleaning compound has on locking torque shall be determined in accordance with Section 4.6.2.1.2 of MIL-S-22473E. Locking Torque After Immersion.

##### **a. Preparation of Test Specimens.**

(1) Threaded fasteners used in the tests shall be 3/8-inch size, 24 threads per inch, unified fine thread series, Class 2 fit (3/8 - 24 UNF2) unoxidized steel bolts and nuts.

(2) The bolts shall have a nominal length of 1 inch (25.4 mm) and may have square or hexagonal heads, and may be unfinished, or finished. The nuts shall be hex head, finished or unfinished. All bolts and nuts used in one series of tests shall be taken from one lot.

(3) All bolts and nuts shall be vapor degreased, stored in an atmosphere of low humidity, and kept clean.

(4) The bolts and nuts shall be 100 percent examined for damaged threads and any such damaged bolts or nuts shall not be used for these tests.

(5) One nut shall be screwed onto each bolt and moved back and forth with the fingers, care being taken to avoid fingerprints on the threads. Bolt-nut pairs showing excessively tight or excessively loose fits, or sticking due to burrs shall be rejected. However, no effort shall be made to select pairs having matched clearances and the threads shall not be cleaned with file, tap or die.

(6) The assemblies shall be stored until time for the application of sealant with the nuts screwed on until 1/2 to 9/16 inch (12.7 to 14.3 mm) of the threaded end of the bolt protrudes.

(7) The assemblies shall be selected at random for the various tests.

b. Procedures.

(1) Grade C-Blue sealing compound shall be used during these tests. Only sealing compound that is within the product expiration date shall be used.

(2) Sufficient sealing compound shall be applied by means of the applicator nozzle supplied with the product to completely cover the protruding threads of the bolt.

(3) The nut shall then be unscrewed over the sealing compound until the end of the nut is flush with the end of the bolt (full nut engagement) and then screwed back onto the bolt until 1/8 to 3/16 inch (3.2 to 4.8 mm) of bolt protrudes to assure complete coverage of the sealing compound in the engaged area.

(4) The coated assemblies shall be allowed to age in air at 70 to 77 °F (21 to 25 °C) for 24 to 26 hours.

(5) After aging, five specimens shall be immersed in the manufacturer's recommended working concentration and temperature for a period of 168 hours. Five control specimens shall be maintained in ambient conditions and five controls immersed in deionized water for 168 hours.

(6) Immediately upon removal of the test specimens from the cleaning product, the locking torque shall be determined. The nuts shall be unscrewed with a torque wrench of suitable capacity and sensitivity. Torque readings shall be taken at 1/4, 1/2, 3/4, and 1 full turn. The average of these 4 readings shall be considered the average locking torque of the specimen and shall be within the range of 4.52 to 11.3 Nm (40 to 100 in.-lb). All test specimens shall be photographically documented immediately upon termination of the test.

(7) Report the following information for each test performed:

(a) Summary of test methods and any deviations from the protocol.

(b) Identification of sample material alloy(s), product temper, and selection of thickness of material tested including reference to product specification.

(c) Specimen details; type and dimensions of test specimen and number of replicates.

(d) Identification of solution tested, concentration used, and diluent used.

- (e) Test conditions; temperature, exposure time, and humidity.
- (f) Identification of testing laboratory and responsible technical point of contact.
- (g) Individual and average test results.
- (h) Results of visual inspections, observations, and discussion of specimen condition.
- (i) Photographic documentation of specimen conditions (specifically any staining, evidence of general or localized attack).

## **SECTION 2. CLEANER EVALUATION**

<b>Alternative Cleaner Test Protocol Cleaner Evaluation</b>	
<b>2.1 Characteristics</b>	
<b>Test</b>	<b>Method</b>
2.1.1 Flash Point	ASTM D-92-90
2.1.2 pH	ASTM E-70-90
2.1.3 Constituents	Fourier Transform Infrared Spectroscopy (FTIR) Analysis
2.1.4 Appearance	MIL-C-29602
2.1.5 Drying Point	ASTM D-86-96
<b>2.2 Safety/Environmental</b>	
<b>Test</b>	<b>Method</b>
2.2.1 Toxicity	AR 40-5
2.2.2 Volatile Organic Compounds	EPA Method 8260A
<b>2.3 Storage</b>	
<b>Test</b>	<b>Method</b>
2.3.1 Cold Stability/Low Temperature Stability	ADS-61 Draft/MIL-PRF-87937C
2.3.2 Heat Stability/Accelerated Storage Stability	ADS-61 Draft/MIL-PRF-87937C
<b>2.4 Surface Cleaning</b>	
<b>Test</b>	<b>Method</b>
2.4.1 Non-Volatile Residues	ASTM D-1353

## **2.1 CHARACTERISTICS**

### **2.1.1 Flash Point**

#### **Objective**

The objective of this test is to determine the flash point characteristics of the manufacturer's suggested working concentration of the cleaning compound.

#### **Criterion**

The flash point of the manufacturer's suggested working concentration of the cleaning compound shall be greater than 212 °F (100 °C).

#### **Test Procedures**

The flash point of the manufacturer's suggested working concentration of the cleaning compound is determined using the method outlined in American Society for Testing and Materials (ASTM) D-92-90 (app B, ref 2.1-1), Standard Test Method for Flash and Fire Points by Cleveland Open Cup.

- a. The test apparatus is prepared, as seen in Figure 2.1-1, the samples are taken, and all cautionary statements in ASTM D-92-90 should be applied.
- b. The test cup is filled with the manufacturer's suggested working concentration of the cleaning compound.
- c. The test flame on the Cleveland test apparatus is lit and adjusted to 3.2 to 4.8 mm (0.125 to 0.1875 in.).
- d. The sample should initially be heated at a rate of 14 to 17 °C (25 to 30 °F) per minute.
- e. During the last 28 °C (50 °F), the sample should be heated at a rate of 5 to 6 °C (9 to 11 °F) per minute.
- f. During the last 28 °C, every 2 °C (5 °F), the test flame is applied across the center of the test solution cup.
- g. The test flame applications are continued until the test solution is raised to 100 °C.
- h. Report the following information for each test performed:
  - (1) Summary of test methods and any deviations from the protocol.
  - (2) Specimen details; type and dimensions of test specimen and number of replicates.

- (3) Identification of solution tested, concentration used, and diluent used.
- (4) Test conditions; temperature, exposure time, and humidity.
- (5) Identification of testing laboratory and responsible technical point of contact.
- (6) Individual and average test results.

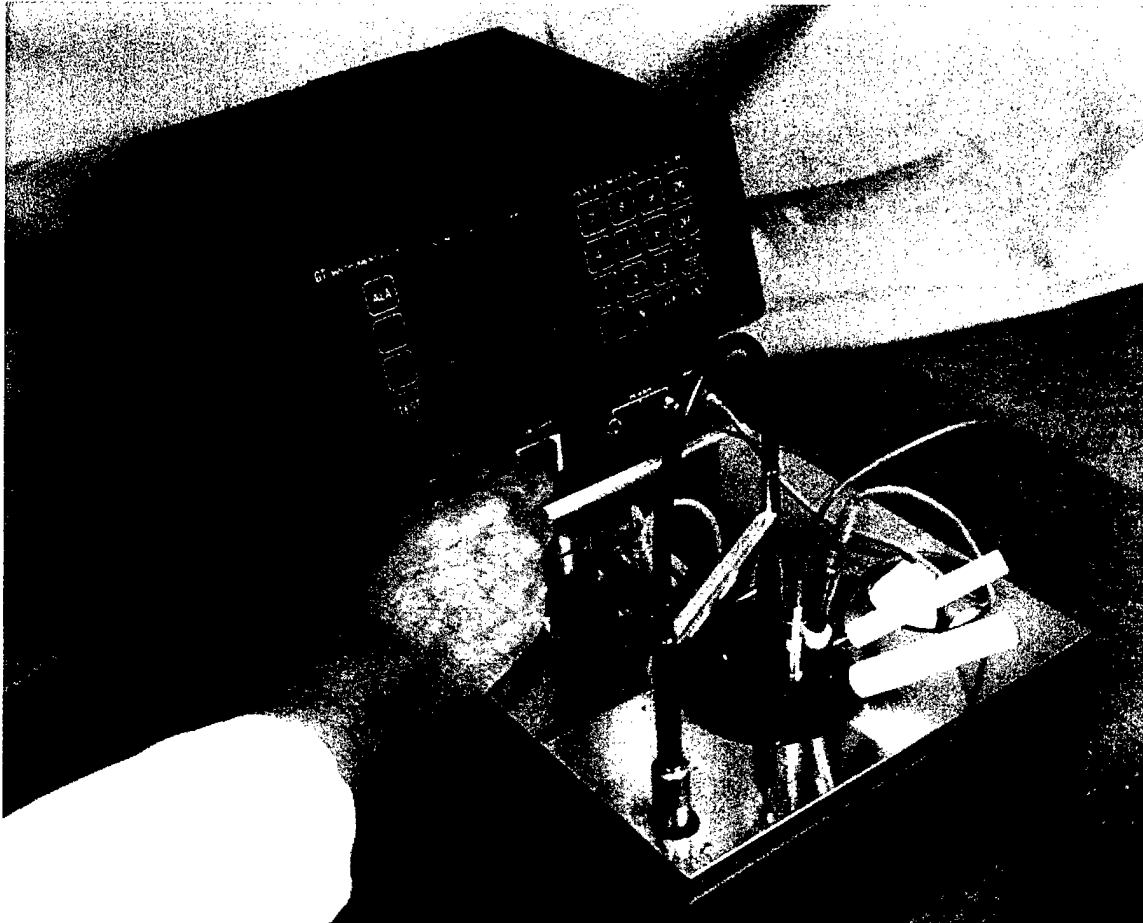


Figure 2.1-1. Cleveland open cup flash point setup.

### 2.1.2 pH

#### Objective

The objective of this test is to determine the pH of the manufacturer's suggested working concentration of the cleaning compound.

### Criterion

The pH value of the manufacturer's suggested working concentration of the cleaning compound shall not differ by more than 1 pH unit from the manufacturer's reported value on the MSDS (Test Protocol).

### Test Procedures

The pH value of the manufacturer's suggested working concentration of the cleaning compound is to be determined using the method outlined in ASTM E-70-90 (app B, ref 2.1-2), Standard Test Method for pH of Aqueous Solutions with the Glass Electrode:

- a. The pH meter is standardized using the methods outlined in ASTM E-70-90.
- b. A clean test cup should be filled with a portion of the manufacturer's suggested working concentration of the cleaning compound and a preliminary value for pH should then be obtained (fig. 2.1-2).
- c. The pH of water samples is measured, as is that of slightly buffered solutions that are in equilibrium with the air, as described in ASTM E-70-90, paragraphs b(1) and (2), except the pH is measured of successive portions of water, with vigorous agitation, until the observed results for two successive portions agree within 0.1 unit.
- d. Report the following information for each test performed:
  - (1) Summary of test methods and any deviations from the protocol.
  - (2) Identification of solution tested, concentration used, and diluent used.
  - (3) Test conditions; temperature, exposure time, and humidity.
  - (4) Identification of testing laboratory and responsible technical point of contact.
  - (5) Individual and average test results.





Figure 2.1-2. pH measurement.

### **2.1.3 Constituents**

#### **Objective**

The objective of this test is to determine the constituents of the manufacturer's suggested working concentration of the cleaning compound.

#### **Criterion**

The manufacturer's suggested working concentration of the cleaning compound shall not contain the following: a) Constituents that are cited in the Clean Air Act, 1990 Amendments for reduction or elimination (Ozone Depleting Chemicals (ODCs), Hazardous Air Pollutants (HAPs) and Volatile Organic Chemicals (VOCs)), b) Constituents that cause the product to be disposed of as a characteristic or listed waste under the Resource Conservation and Recovery Act (RCRA), c) Constituents that are listed as known or suspected carcinogens by the National Toxicology Program, d) Constituents that are listed as Total Toxic Organic (TTO) in 40 CFR Part 122, Appendix D (app B, ref 2.1-3) (Test Protocol).

## Test Procedures

- a. The MSDS for the manufacturer's suggested working concentration of the cleaning compound should be reviewed for basic information about the cleaner.
- b. The manufacturer's suggested working concentration of the cleaning compound is then submitted for Fourier Transform Infrared Spectroscopy (FTIR) analysis. The analysis should include the comparison against an extensive library of materials that meet the criteria requirements (ODCs, HAPs, VOCs, RCRA, etc.).
- c. The FTIR data are then compared to the MSDS and the Toxicity Certification for discrepancies.
- d. Report the following information for each test performed:
  - (1) Summary of test methods and any deviations from the protocol.
  - (2) Identification of solution tested, concentration used, and diluent used.
  - (3) Identification of testing laboratory and responsible technical point of contact.

### **2.1.4 Appearance**

#### Objective

The objective of this test is to determine the appearance of the manufacturer's suggested working concentration of the cleaning compound.

#### Criterion

The appearance of the manufacturer's suggested working concentration of the cleaning compound shall be free of separation and be evenly dispersed (Test Protocol).

## Test Procedures

The appearance of the manufacturer's suggested working concentration of the cleaning compound is to be determined using a modified version of MIL-C-29602, paragraph 4.5.2.1 (app B, ref 2.1-4).

- a. The manufacturer's suggested working concentration of the cleaning compound is mixed, if not already supplied in this form, and observed for separations or colloidal dispersions.
- b. A uniform 1-liter sample is then taken (using calowasa) and placed into a clean glass jar with a screw-type lid.

- c. The closed sample is allowed to sit undisturbed for 48 hours at ambient conditions.
- d. With minimal disturbance, the sample is then observed for separations or colloidal dispersions. Appearance at this time should be photographically documented.
- e. Report the following information for each test performed:
  - (1) Summary of test methods and any deviations from the protocol.
  - (2) Identification of solution tested, concentration used, and diluent used.
  - (3) Test conditions; temperature, exposure time, and humidity.
  - (4) Identification of testing laboratory and responsible technical point of contact.
  - (5) Results of visual inspections, observations, and discussion of specimen condition.
  - (6) Photographic documentation of specimen conditions.

### **2.1.5 Drying Point**

#### **Objective**

The objective of this test is to determine the drying point of the manufacturer's suggested working concentration of the cleaning compound.

#### **Criterion**

The manufacturer's suggested working concentration of the cleaning compound shall not exceed 206.7 °C (404 °F) drying point (Test Protocol).

#### **Test Procedures**

The drying point of the manufacturer's suggested working concentration of the cleaning compound is determined using ASTM D-86-96 (app B, ref 2.1-5), Standard Test Method for Distillation of Petroleum Products.

- a. The test setup should be assembled in accordance with the instructions for Group IV.
- b. Heat is applied to the distillation flask and contents. The heating at this stage is regulated to reach the initial boiling point in 5 to 15 minutes from initial heating.
- c. The heating rate is adjusted after reaching the initial boiling point to a uniform average rate of condensation from 5 percent recovered to 5 mL residue in the flask of 4 to 5 mL/minute.

d. The final boiling point (dry point) is recorded. The drying point is the thermometer reading that is observed at the instant the last drop of liquid evaporates from the lowest point in the flask. Any drops or film of liquid on the side of the flask or on the thermometer are disregarded.

e. Report the following information for each test performed:

- (1) Summary of test methods and any deviations from the protocol.
- (2) Identification of solution tested, concentration used, and diluent used.
- (3) Test conditions; temperature, exposure time, and humidity.
- (4) Identification of testing laboratory and responsible technical point of contact.
- (5) Individual and average test results.
- (8) Results of visual inspections, observations and discussion of specimen condition.

## 2.2 SAFETY/ENVIRONMENT

### 2.2.1 Toxicity

#### Objective

The objective of this test is to determine if a toxicity clearance can be given for the manufacturer's suggested working concentration of the cleaning compound.

#### Criterion

The toxicity of the manufacturer's suggested working concentration of the cleaning compound shall conform to AR 40-5 (app B, ref 2.2-1) and shall have no adverse effects on the health of personnel or the environment when used properly and with the appropriate personal protection equipment (PPE) (Test Protocol).

#### Test Procedures

Toxicological Clearance for any potentially hazardous product to be used by U. S. Army military personnel is granted or denied by the CHPPM using the process in AR 40-5. A Toxicological Clearance involves a toxicity evaluation of materials prior to introduction into the Army supply system. The program manager is responsible for identifying technically feasible materials and requesting a Toxicological Clearance for use of those materials.

a. CHPPM toxicity evaluations require the following:

- (1) Final chemical formulation (handled as proprietary if required).
- (2) Identity and application of new solvent; identity of solvent being replaced, if applicable.
- (3) Reports from manufacturers pertaining to use of the solvent in the commercial market and material safety data sheets (MSDSs).
- (4) Available human and animal toxicity studies and epidemiology information.

b. A toxicity evaluation is performed and clearances are conditionally approved based upon the solvent application or use condition. The CHPPM Toxicology Directorate homepage lists the conditionally approved, disapproved and 'in progress' toxicity clearances. This listing can be found at: <http://chppm-www.apgea.army.mil/tox/>.

c. A toxicity clearance request should be forwarded from the program manager, through the supporting Surgeon's office, to CHPPM. The following format should be used:

DEPARTMENT OF THE ARMY  
US ARMY COMMAND  
SOMEWHERE, USA 55515

AMMX-XT-PM

MEMORANDUM THRU

Commander, US Army Materiel Command, ATTN: AMCRDA-TE-E  
(Mr. Joseph A. Macko, Jr.), 5001 Eisenhower Ave., Alexandria, VA 22333-0001

Commander, US Army Materiel Command, ATTN: AMCSG-I, 5001 Eisenhower Ave.,  
Alexandria, VA 22333-0001

FOR Commander, US Army Center for Health Promotion and Preventive Medicine,  
ATTN: MCHB-TS-T, Aberdeen Proving Ground, MD 21010-5403

SUBJECT: Request for Toxicological Clearance for **[subject solvent]**

1. Request a toxicity evaluation be performed and a Toxicological Clearance be issued for [subject solvent], a product being considered for use in [state application]. This product will replace [chemical name] in this particular application.
2. Enclosed is the technical information on the product, provided by the manufacturer. The manufacturer is XYZ, Inc., Street address, City, State. The technical POC at XYZ is [name] at [phone number]. The POC in this office is [name] at Commercial [phone number] and DSN [phone number].

NAME  
RANK  
TITLE

## **2.2.2 Volatile Organic Compounds (VOCs)**

### **Objective**

The objective of this test is to determine the VOC content of the manufacturer's suggested working concentration of the cleaning compound.

### **Criterion**

The manufacturer's suggested working concentration of the cleaning compound shall contain less than 0.2082 lb/gal. (25 gm/L) of Volatile Organic Compounds (VOCs) (Test Protocol).

### **Test Procedures**

**VOC Content.** The VOC content of the cleaner shall be determined using Environmental Protection Agency (EPA) Method 8260A, Volatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS): Capillary Column Technique (app B, ref 2.2-3). Since the method is lengthy, only a summary is presented in the following paragraphs. This method and all precautions will be followed as outlined in EPA Method 8260A.

a. The volatile compounds are introduced into the gas chromatograph by the purge-and-trap method or by direct injection (in limited applications). Purged sample components are trapped in a tube containing suitable sorbent materials. When purging is complete, the sorbent tube is heated and backflushed with helium to desorb trapped sample components. The analytes are desorbed directly to a large-bore capillary or cryofocused on a capillary precolumn before being flash-evaporated to a narrow-bore capillary for analysis. The column is temperature programmed to separate the analytes, which are then detected with a mass spectrometer interfaced to the gas chromatograph. Wide-bore capillary columns require a jet separator, whereas narrow-bore capillary columns can be directly interfaced to the ion source.

b. If the sample introduction techniques in paragraph (a) are not applicable, a portion of the sample is dispersed in solvent to dissolve the volatile organic constituents. A portion of the solution is combined with organic-free reagent water in the purge chamber. It is then analyzed by purge-and-trap GC/MS, following the normal water method.

c. Analytes eluted from the capillary column are introduced into the mass spectrometer via a jet separator or direct connection. Identification of target analytes is accomplished by comparing their mass spectra with the electron impact (or electron impact-like) spectra or authentic standards. Quantitation is accomplished by comparing the response of a major (quantitation) ion relative to an internal standard with a five-point calibration curve.

d. The method includes specific calibration and quality control steps that replace the general requirements in EPA Method 8000 (app B, ref 2.2-4).

## 2.3 STORAGE

### 2.3.1 Cold Stability

#### Objective

The objective of this test is to determine the cold stability of the manufacturer's suggested working concentration of the cleaning compound.

#### Criterion

The cold stability of the manufacturer's suggested working concentration of the cleaning compound shall be such that the cleaning compound returns to its original homogeneous condition after exposure to cold environments (Test Protocol). The cleaner shall be evaluated according to both of the following test methods.

#### Test Procedures

##### Method A - Cold Stability.

The cold stability of the manufacturer's working concentration of the cleaning compound is determined using MIL-PRF-87937C, paragraph 4.5.6 (app B, ref 2.3-1).

- a. A 50-mL sample of the manufacturer's working concentration of the cleaning compound is placed in a suitable, clean test tube.
- b. The test tube is then cooled to  $0 \pm 2$  °C (32 °F).
- c. The test tube is held at this temperature for 1 hour.
- d. The test tube is then allowed to return to the ambient (room) temperature.
- e. The steps in paragraph c through e are repeated four more times (a total of five cycles).
- f. The manufacturer's working concentration of the cleaning compound should then be observed for homogeneity or any changes noted from the original solutions. Appearance at this time should be photographically documented.
- g. Report the following information for each method:
  - (1) Summary of test methods and any deviations from the protocol.
  - (2) Identification of solution tested, concentration used, and diluent used.



- (3) Test conditions; temperature, exposure time, and humidity.
- (4) Identification of testing laboratory and responsible technical point of contact.
- (5) Results of visual inspections, observations, and discussion of specimen condition.

#### Method B - Low Temperature Stability.

The low temperature stability of the manufacturer's working concentration of the cleaning compound is determined using ADS-61-PRF, paragraph 4.5.5 (app B, ref 2.3-2).

a. A 50-mL sample of the manufacturer's working concentration of the cleaning compound is placed in a suitable, clean test tube.

b. The test tube is then cooled to  $-18 \pm 5^{\circ}\text{C}$  ( $0 \pm 9^{\circ}\text{F}$ ).

c. The test tube is held at this temperature for 1 hour.

d. The test tube is then allowed to return to the ambient (room) temperature.

e. Invert the test tube five times.

f. The manufacturer's working concentration of the cleaning compound should then be observed for homogeneity or any changes noted from the original solutions. Appearance at this time should be photographically documented.

g. Report the following information for each method:

- (1) Summary of test methods and any deviations from the protocol.
- (2) Identification of solution tested, concentration used, and diluent used.
- (3) Test conditions; temperature, exposure time, and humidity.
- (4) Identification of testing laboratory and responsible technical point of contact.
- (5) Results of visual inspections, observations, and discussion of specimen condition.

### 2.3.2 Heat Stability

#### Objective

The objective of this test is to determine the heat stability of the manufacturer's suggested working concentration of the cleaning compound.

## Criterion

The heat stability of the manufacturer's suggested working concentration of the cleaning compound shall be such that the cleaner shows no marked color changes or precipitation, and shall not corrode or stain the 1020 steel strip (a slight darkening shall not be objectionable). Layering or separation will constitute failure if it does not return to its original homogenous state upon cooling (Test Protocol).

## Test Procedures

### Method A - Heat Stability (MIL-PRF-87937C).

The heat stability of the manufacturer's working concentration of the cleaning compound is to be determined using MIL-PRF-87937C, paragraph 4.6.5 (app B, ref 2.3-1).

a. 141.75 grams (4.97 oz) of the manufacturer's suggested working concentration of the cleaning compound should be placed into each of two clean 255-mL (12-oz) clear glass bottles approximately 24 cm (9.5 in.) high with a 6.35-cm (2.5-in.) diameter.

b. One bottle containing the manufacturer's suggested working concentration of the cleaning compound is sealed with a screw-type cap and stored in a dark place at standard conditions for six days (144 hr) for reference purposes.

c. A strip of 1020 steel (15.24 by 1.27 by 0.05 cm (6.0 by 0.5 by 0.02 in.)), conforming to SAE-AMS 5046 (app B, ref 1.1-8), is then cleaned by abrasively polishing it to remove the surface scale and corrosion. The strip should then be immersed in PD-680 for 1 minute followed by immersion in isopropyl alcohol (TT-I-735, grade A) for 1 minute.

d. The test strip should be placed into the second bottle of the manufacturer's suggested working concentration of the cleaning compound at standard conditions, and the bottle should be sealed. The solution should cover approximately 1/2 of the test strip.

e. The bottle is then shaken thoroughly for 1 minute and placed into a bath maintained at  $46 \pm 2$  °C ( $115 \pm 3$  °F) for 5 hours. Upon removal, the bottle is allowed to cool to ambient conditions for 19 hours.

f. The heating/cooling cycle shall be repeated five times. Care is taken to not shake the bottle and wet the unexposed section of the test strip.

g. On the sixth day the steel strip is removed and the portion of the strip which was immersed in the manufacturer's suggested working concentration of the cleaning compound and the portion that was exposed to the vapor (the cleaning compound/air mixture above the liquid level) are inspected. Any corrosion pitting or discoloration institutes a failure.

h. The bottle is then resealed without the steel strip.

i. The control bottle and the test bottle are thoroughly shaken for 1 minute and then allowed to remain undisturbed for 1 hour at room temperature.

j. The bottles are then examined for any marked change in color, precipitation, layering, or separation. All test coupons should be photographically documented immediately upon termination of the test. Any marked change in color, precipitation, layering or separation constitutes a failure.

k. Report the following:

(1) Summary of test methods and any deviations from the protocol.

(2) Identification of sample material alloy(s), product temper, and selection of thickness of material tested including reference to product specification.

(3) Specimen details; type and dimensions of test specimen and number of replicates.

(4) Identification of solution tested, concentration used, and diluent used.

(5) Test conditions; temperature, exposure time, and humidity.

(6) Identification of testing laboratory and responsible technical point of contact.

(7) Individual and average test results.

(8) Results of visual inspections, observations, and discussion of specimen condition.

(9) Photographic documentation of specimen conditions (specifically any staining, evidence of general corrosion, etching, pitting, or localized attack).

#### Method B - Accelerated Storage Stability (ADS-61-PRF).

The accelerated storage stability of the manufacturer's working concentration of the cleaning compound is to be determined using ADS-61-PRF, paragraph 4.5.4 (app B, ref 2.3-2).

a. Pour a 150 mL (5 oz) portion of a well shaken working concentration of the cleaner into each of two chemically clean 255 mL (12 oz) pressure resistant clear glass bottles, approximately 24.1 cm (9.5 in.) in height and 6.4 cm (2.5 in.) in outside diameter.

b. Cap one bottle and store in the dark for at least 6 days at room temperature.

c. Polish a strip of steel 15.2 by 1.27 by 0.05 cm (6 by 0.5 by 0.02 in.) conforming to SAE-AMS 5046 with 280-grit silicon carbide paper to remove surface contamination and then clean by boiling for one minute in mineral spirits, and one minute in isopropyl alcohol.

d. Place the steel strip in the other test bottle and cap the bottle. Roll the capped bottle containing the steel strip on its side to completely coat the steel strip.

e. Place the upright capped bottle containing the steel strip in an oven and heat at a uniform rate to a temperature of  $60 \pm 2$  °C ( $140 \pm 4$  °F) over a period of 5 hours.

f. Keep at this temperature for 3 hours. Do not apply heat to the bath overnight.

g. Repeat the above heating procedure each day for 5 days.

h. On the sixth day, remove the bottle from the bath, uncap, examine for separation and withdraw the steel strip from the bottle. Separation into layers shall be cause for rejection.

i. Examine the steel strip for evidence of corrosion or discoloration.

j. Cap the open bottle and shake the two bottles thoroughly for one minute, then allow them to remain undisturbed for one hour at room temperature and then examine. Any marked change in the color and uniformity of the heated sample shall be considered as showing unsatisfactory stability properties.

k. Report the following:

(1) Summary of test methods and any deviations from the protocol.

(2) Identification of sample material alloy(s), product temper, and selection of thickness of material tested including reference to product specification.

(3) Specimen details; type and dimensions of test specimen and number of replicates.

(4) Identification of solution tested, concentration used, and diluent used.

(5) Test conditions; temperature, exposure time, and humidity.

(6) Identification of testing laboratory and responsible technical point of contact.

(7) Individual and average test results.

(8) Results of visual inspections, observations, and discussion of specimen condition.

(9) Photographic documentation of specimen conditions (specifically any staining, evidence of general corrosion, etching, pitting, or localized attack).

## 2.4 SURFACE CLEANING

### 2.4.1 Nonvolatile Residue

#### Objective

The objective of this test is to determine the nonvolatile residue (NVR) characteristics of the manufacturer's suggested working concentration of the cleaning compound.

#### Criterion

The nonvolatile residue of the manufacturer's suggested working concentration of the cleaning compound shall be less than 10 mg of residue per 100 mL of solution (Test Protocol).

#### Test Procedures

The nonvolatile residue characteristics of the manufacturer's suggested working concentration of the cleaning compound is determined according to the method given in ASTM D-1353.

- a. Five grams  $\pm$  0.001 grams of the manufacturer's suggested working concentration of the cleaning compound is placed in a porcelain dish about 6 to 8 cm in diameter and about 2 to 4 cm in depth.
- b. Dry to a constant weight in an air oven at a temperature of  $105 \pm 2$  °C for 1 hour.
- c. Constant weight is attained when successive heating for 1-hour periods shows a loss (or gain) of not more than 0.1 percent.
- d. Nonvolatile residue determinations shall be made on three samples and the average shall be reported. If the two weights differ by more than 0.5 percent (absolute) the procedure shall be repeated.
- e. The nonvolatile content of each sample shall be calculated as follows:

$$\% \text{ NVM} = \left[ \frac{A}{B} \right] 100$$

where:

- A = Weight of residue.  
B = Weight of sample.  
%NVM = Percent nonvolatile residue.

- f. Repeat the procedure for a total of three replicates.
- g. Report the following information for each test performed:
  - (1) Summary of test methods and any deviations from the protocol.
  - (2) Identification of solution tested, concentration used, and diluent used.
  - (3) Test conditions; temperature, exposure time and humidity.
  - (4) Identification of testing laboratory and responsible technical point of contact.
  - (5) Individual and average test results.
  - (6) Results of visual inspections, observations, and discussion of specimen condition.

### SECTION 3. APPENDIXES

#### APPENDIX A. CRITERIA

**TEST 1.1.1** The manufacturer's suggested working concentration of the cleaning compound shall not show any indication of staining, etching, pitting, or localized attack on the subtest panels, or cause weight change to an average of three (3) test panels greater than that shown in Table 1. (Test Protocol). After salt fog testing, the corrosion on the test panels shall not be worse than the panels immersed in the PD680 solvent.

TABLE 1.1.1-1. ALLOY AND MAXIMUM  
AVERAGE WEIGHT LOSS

Alloy	Weight Loss, mg/cm <sup>2</sup> /168 hr
PH 13-8 Mo	0.49
C-250	0.49
Magnesium (AZ31B-H24) <sup>a</sup>	0.70
AL7075-T6	0.49
Titanium 6AL-4V	0.35
Steel 4340	0.49
Steel 4340 Zinc- Phosphate Coated	<sup>b</sup> 0.00
Steel 4340 Manganese- Phosphate Coated	<sup>b</sup> 0.00
Copper Alloy (Brass) UNS C36000	<sup>b</sup> 0.00
Copper Alloy UNS C10100 HO2 HH	<sup>b</sup> 0.00
Silver Plated Steel MIL STD-171E, para 5.1	<sup>b</sup> 0.00
AL-2024-T3	0.49
AL-5052-H32	0.49
AL-6061-T6	0.49

<sup>a</sup>AMS 4377 surface treated in accordance with AMS-M-3171 Type III.

<sup>b</sup>No criteria specified.

**TEST 1.1.2** The manufacturer's suggested working concentration of the cleaning compound shall not show any indication of staining, etching, pitting, or localized attack on the test panels, or cause weight change to an average of three (3) test panels greater than 0.14 mg/cm<sup>2</sup> for 24 hours.

**TEST 1.1.3** The manufacturer's maximum suggested use concentration shall not cause weight change of the average of the three (3) test panels greater than 0.14 mg/cm<sup>2</sup>/24 hr.

**TEST 1.1.4** The manufacturer's maximum recommended concentration plus 10% of the cleaning compound tested at the maximum recommended operating temperature plus 25°F shall not show any indication of corrosion on the test panels or cause any average stock loss greater than amounts given in table 1.1.4-2.

**TEST 1.1.5** The manufacturer's suggested working concentration of the cleaning compound shall not cause a corrosion rating greater than two (2) on any test panel (Test Protocol). The corrosion rating on the set of test panels from the test solution group shall not be worse than the corrosion rating of the Reagent water, control group. Any corrosion in excess of that shown by the control group shall be cause for rejection. Pitting corrosion of any panel gets a severity rating of 4.

**TEST 1.1.6** The manufacturer's suggested working concentration of the cleaning compound shall not cause hydrogen embrittlement of cadmium plated ANSI 4340 steel (Test Protocol).

**TEST 1.1.7** The manufacturer's suggested working concentration of the cleaning compound shall not cause streaking, stains or other deposits on unpainted surfaces that cannot be easily removed with water (Test Protocol).

**TEST 1.1.8** The manufacturer's suggested working concentration of the cleaning compound shall not cause stress corrosion (Test Protocol).

**TEST 1.1.9** The manufacturer's suggested working concentration of the cleaning compound shall not cause a copper corrosion rating higher than 1a (Test Protocol).

**TEST 1.1.10** The manufacturer's suggested working concentration of the cleaning compound shall not cause any steel corrosion. If lightly rubbing the specimens with 00 steel wool does not remove any light stains or cleaner residue, the specimen is considered corroded.

**TEST 1.1.11** The manufacturer's suggested working concentration of the cleaning compound shall not cause corrosion on a bimetallic couple (Test Protocol). Any evidence of corrosion, pitting, or other attack in the test area constitutes a failure to meet this criterion.

**TEST 1.2.1** The manufacturer's suggested working concentration of the cleaning compound shall not cause streaking, discoloration, blistering or a permanent decrease in film hardness of more than one (1) pencil hardness level on any painted surfaces. This criterion does not apply to MIL-L-46159 (Test Protocol) (app C, ref 1.2-8).

**TEST 1.3.1** The manufacturer's suggested working concentration of the cleaning compound shall not cause cracking, discoloration, dissolution of the tubing and wire coating, dielectric breakdown of the insulated wire in excess of that produced by distilled water (Test Protocol).



**TEST 1.3.2** The manufacturer's suggested working concentration of the cleaning compound shall not cause stress crazing or staining of acrylic plastics (Test Protocol).

**TEST 1.3.3** The manufacturer's suggested working concentration of the cleaning compound shall not cause stress crazing or staining of polycarbonate plastics (Test Protocol).

**TEST 1.3.4** The manufacturer's suggested working concentration of the cleaning compound shall not change the durometer hardness of polysulfide sealants more than 5 units (Test Protocol).

**TEST 1.3.5.1** The manufacturer's suggested working concentration of the cleaning compound shall not change the durometer hardness of rubber materials more than 5 units (Test Protocol).

**TEST 1.3.5.2** The manufacturer's maximum recommended use concentration of the cleaning compound shall not cause a greater compression set than the compression set of the control sample tested in dry air.

**TEST 1.3.5.3** The manufacturer's maximum recommended use concentration of the cleaning compound shall not change the mass, volume or dimensions of rubber materials.

**TEST 1.3.5.4** The manufacturer's maximum recommended use concentration of the cleaning compound shall not increase or decrease the tensile strength, ultimate elongation or hardness of the rubber material.

**TEST 1.3.6.1** The manufacturer's maximum recommended use concentration of the cleaning solution shall not cause the tensile strength or elongation of the PCTFE to fail to meet the minimum requirements of AMS-3650 (app C, ref 1.3-18). The minimum average tensile strength at  $23 \pm 1$  °C ( $73 \pm 2$  °F) shall not be less than 4500 psi (31.0 MPa). The minimum percent elongation at  $23 \pm 1$  °C ( $73 \pm 2$  °F) shall not be less than 100%.

**TEST 1.3.6.2** The manufacturer's maximum recommended use concentration of the cleaning solution shall not cause the impact strength of the PCTFE to fail to meet the minimum requirements of AMS 3650 Rev C (app C, ref 1.3-18). The minimum impact strength at  $23 \pm 1$  °C ( $73 \pm 2$  °F) shall not be less than 1.25 foot pounds (66.75 J/m)/inch of notch width.

**TEST 1.3.6.3** The manufacturer's maximum recommended use concentration of the cleaning solution shall not cause the specific gravity of the PCTFE to fail to meet the minimum requirements of AMS 3650 (app C, ref 1.3-18). The specific gravity at 23/23 °C (73/73 °F) shall be in the range 2.08 - 2.18.

**TEST 1.3.6.4** The manufacturer's maximum recommended use concentration of the cleaning solution shall not cause the dimensional stability of the PCTFE to fail to meet the minimum requirements of AMS 3650 (app C, ref 1.3-18). No dimensions shall change more than 0.003 inch per inch (0.003 mm/mm) measured at 20° - 30 °C (68° - 86 °F) before and after exposure to the test cleaner solution.

**TEST 1.3.7** The manufacturer's suggested working concentration of the cleaning compound shall not reduce the locking torque of Grade C-Blue unpolymerized sealing compound as presented in Table 1, Section 1.2.1 of Military Specification MIL-S-22473E, Sealing, Locking, and Retaining Compounds: (Single-Component) (app C, ref 1.3-22).

**TEST 2.1.1** The flash point of the manufacturer's suggested working concentration of the cleaning compound shall be greater than 212 °F (100 °C).

**TEST 2.1.2** The pH value of the manufacturer's suggested working concentration of the cleaning compound shall not differ by more than 1 pH unit from the manufacturer's reported value on the MSDS (Test Protocol).

**TEST 2.1.3** The manufacturer's suggested working concentration of the cleaning compound shall not contain the following: a) Constituents that are cited in the Clean Air Act, 1990 Amendments for reduction or elimination (Ozone Depleting Chemicals (ODCs), Hazardous Air Pollutants (HAPs) and Volatile Organic Chemicals (VOCs)), b) Constituents that cause the product to be disposed of as a characteristic or listed waste under the Resource Conservation and Recovery Act (RCRA), c) Constituents that are listed as known or suspected carcinogens by the National Toxicology Program, d) Constituents that are listed as Total Toxic Organic (TTO) in 40 CFR Part 122, Appendix D (app C, ref 2.1-3) (Test Protocol).

**TEST 2.1.4** The appearance of the manufacturer's suggested working concentration of the cleaning compound shall be free of separation and be evenly dispersed (Test Protocol).

**TEST 2.1.5** The manufacturer's suggested working concentration of the cleaning compound shall not exceed 206.7 °C (404 °F) drying point (Test Protocol).

**TEST 2.2.1** The toxicity of the manufacturer's suggested working concentration of the cleaning compound shall conform to AR 40-5 (app C, ref 2.2-1) and shall have no adverse effects on the health of personnel or the environment when used properly and with the appropriate personal protection equipment (PPE) (Test Protocol).

**TEST 2.2.2** The manufacturer's suggested working concentration of the cleaning compound shall contain less than 0.2082 lb/gal. (25 gm/L) of Volatile Organic Compounds (VOCs) (Test Protocol).

**TEST 2.3.1** The cold stability of the manufacturer's suggested working concentration of the cleaning compound shall be such that the cleaning compound returns to its original homogeneous condition after exposure to cold environments (Test Protocol). The cleaner shall be evaluated according to both of the following test methods.

**TEST 2.3.2** The heat stability of the manufacturer's suggested working concentration of the cleaning compound shall be such that the cleaner shows no marked color changes or precipitation, and shall not corrode or stain the 1020 steel strip (a slight darkening shall not be objectionable). Layering or separation will constitute failure if it does not return to its original homogenous state upon cooling (Test Protocol).

**TEST 2.4.1** The nonvolatile residue of the manufacturer's suggested working concentration of the cleaning compound shall be less than 10 mg of residue per 100 mL of solution (Test Protocol).

## APPENDIX B. REFERENCES

- 1.1-1 AMS 4377, Sheet And Plate, Magnesium Alloy 3.0AL - 1.0ZN - 0.20MN (AZ31B-H24) Cold Rolled, Partially Annealed.
- 1.1-2 AMS M 3171, Magnesium Alloy, Processes For Pretreatment And Prevention Of Corrosion On.
- 1.1-3 ASTM F-483-98, Standard Test Method For Total Immersion Corrosion Test For Aircraft Maintenance Chemicals.
- 1.1-4 MIL-DTL-16232G, Phosphate Coatings, Heavy, Manganese Or Zinc Base (For Ferrous Metals) (No S/S Document).
- 1.1-5 ASTM D-235, Mineral Spirits (Petroleum Spirits) (Hydrocarbon Dry Cleaning Solvent).
- 1.1-6 ASTM B-117-95, Standard Practice For Operating Salt Spray (Fog) Apparatus.
- 1.1-7 ASTM D-329, Acetone.
- 1.1-8 SAE AMS 5046 Steel, Sheet Strip And Plate, Carbon Steel (SAE 1020 and 1025) Annealed.
- 1.1-9 ASTM A-153, Zinc Coating (Hot-Dip) On Iron And Steel Hardware.
- 1.1-10 ASTM D-1193, Standard Specification For Reagent Water.
- 1.1-11 ASTM F-1111-88 (1998), Standard Test Method For Corrosion Of Low-Embrittling Cadmium Plate By Aircraft Maintenance Chemicals.
- 1.1-12 MIL-S-18729, Steel Plate, Sheet, And Strip, Alloy, 4130, Aircraft Quality (S/S By SAE AMS 6350, SAE-AMS 6351 Or SAE AMS 6345).
- 1.1-13 SAE ARP 1755-00, Effects of Cleaning Agents on Aircraft Engine Materials; Stock Loss Test Method.
- 1.1-14 MIL-STD-171E, Finishing Of Metal And Wood Surfaces.
- 1.1-15 ASTM F-1110-90 (1998), Standard Test Method For Sandwich Corrosion Test.
- 1.1-16 MIL-A-8625, Anodic Coatings For Aluminum And Aluminum Alloys.
- 1.1-17 ASTM G-46, Standard Practice Examination And Evaluation Of Pitting Corrosion.

- 1.1-18 ASTM F-519-97, Standard Test Method For Mechanical Hydrogen Embrittlement Testing of Plating Processes And Aircraft Maintenance Chemicals.
- 1.1-19 ASTM F-485-98, Standard Test Method For Effects Of Cleaners On Unpainted Aircraft Surfaces, Modified By The Test Plan.
- 1.1-20 ASTM G-30-97, Standard Practice For Making And Using U-Bend Stress Corrosion Test Specimens.
- 1.1-21 ASTM G-44-99, Metals And Alloys By Alternate Immersion In 3.5 Percent Sodium Chloride Solution, Exposure Of.
- 1.1-22 ASTM D-6361-98, Standard Guide For Selecting Cleaning Agents And Processes, Appendix XI.
- 1.1-23 ASTM F-945, Standard Test Method For Stress-Corrosion Of Titanium Alloys By Aircraft Engine Cleaning Materials.
- 1.1-24 ASTM D-130-94 (2000), Copper Corrosion From Petroleum Products By The Copper Strip Tarnish Test, Detection Of.
- 1.1-25 FED STD-791C, Test Method 5322.2, Lubricants, Liquid Fuels, And Related Products; Methods Of Testing.
- 1.1-26 ASTM A-322, Steel Bars, Alloy, Standard Grades, Standard Specification For.
- 1.1-27 MIL-PRF-63460E, Lubricant, Cleaner And Preservative For Weapons And Weapons Systems (Metric).
- 1.1-28 ASTM D-1748, Rust Protection By Metal Preservatives In The Humidity Cabinet.
- 1.1-29 Federal Specification TT-N-95, Naphtha; Aliphatic.
- 1.1-30 Federal Specification O-M-232, Methanol (Methyl Alcohol).
- 1.2.-1 MIL-L-46159, Lacquer, Acrylic, Low Reflective (S/S By MIL-C-46168 or MIL-C-53039).
- 1.2.-2 ASTM F-502-93 (1998), Aircraft, Painted Surfaces, Effects Of Cleaning And Chemical Maintenance Materials On.
- 1.2.-3 MIL-C-81706, Chemical Conversion Materials For Coating Aluminum And Aluminum Alloys (No S/S Document).
- 1.2.-4 MIL-PRF-23377, Primer Coatings: Epoxy, High-Solids.

- 1.2-5 MIL-PRF-22750, Coating, Epoxy, High-Solids.
- 1.2-6 MIL-PRF-85285, Coating: Polyurethane, High-Solids.
- 1.2-7 MIL-C-46168, Coating, Aliphatic Polyurethane, Chemical Agent Resistant.
- 1.2-8 MIL-P-14105, Paint, Heat-Resisting (For Steel Surfaces).
- 1.2-9 MIL-E-52891B, Enamel, Lusterless, Zinc Phosphate, Styrenated Alkyd Type.
- 1.3-1 ASTM F-484-83 (1998), Plastics, Acrylic, In Contact With Liquid Or Semi Liquid Compounds, Stress Crazing Of, Standard Test Method For - 30 Sep 83.
- 1.3-2 MIL-PRF-5425, Plastic, Sheet, Acrylic, Heat Resistant.
- 1.3-3 MIL-PRF-8184, Plastic Sheet, Acrylic, Modified.
- 1.3-4 MIL-PRF-25690B, Plastic, Sheet And Formed Parts, Modified Acrylic Base, Monolithic, Crack Propagation Resistant.
- 1.3-5 MIL-P-83310, Plastic Sheet, Polycarbonate, Transparent.
- 1.3-6 MIL-PRF-81733-D, Sealing And Coating Compound, Corrosion Inhibitive.
- 1.3-7 MIL-S-8802 Class B-2, Sealing Compound, Temperature-Resistant, Integral Fuel Tanks And Fuel Cell Cavities, High-Adhesion (S/S By SAE AMS S 8802).
- 1.3-8 ASTM D-2240-95, Standard Test Method For Rubber Property - Durometer Hardness.
- 1.3-9 ASTM D-395, Standard Test Method For Rubber Property - Compression Set.
- 1.3-10 ASTM D-471, Standard Test Method For Rubber Property - Effect Of Liquid.
- 1.3-11 SAE AMS 3204, Rubber, Synthetic Low-Temperature Resistant 25-35.
- 1.3-12 AMS 3209, Chloroprene (Cr) Rubber Weather Resistant 65-75.
- 1.3-13 MIL-R-83248C, Rubber, Fluorocarbon Elastomer, High Temperature, Fluid, And Compression Set Resistant.
- 1.3-14 ASTM Test Methods D 412, Rubber, Vulcanized And Thermoplastic Elastomers - Tension.
- 1.3-15 AMS 3650, Rods, Sheets, And Molded Shapes, Polychlorotrifluoroethylene (PCTFE) Unplasticized.

- 1.3-16 ASTM D-638, Tensile Properties Of Plastics.
- 1.3-17 ASTM D-256, Plastics, Determining The Izod Pendulum Impact Resistance Of.
- 1.3-18 ASTM D-792-98, Density And Specific Gravity (Relative Density) Of Plastics By Displacement.
- 1.3-19 MIL-S-22473E, Sealing, Locking, And Retaining Compounds: (Single-Component).
- 2.1-1 ASTM D-92-90, Flash And Fire Points By Cleveland Open Cup.
- 2.1-2 ASTM E-70-90, Electrode, Ph Of Aqueous Solutions With The Glass.
- 2.1-3 40 CFR Part 122, Appendix D, Table II Organic Toxic Pollutants In Each Of Four Fractions In Analysis By Gas Chromatography/Mass Spectroscopy (GS/MS), 1997.
- 2.1-4 MIL-C-29602, Cleaning Compounds, For Parts Washers And Spray Cabinets.
- 2.1-5 ASTM D-86-96, Standard Test Method For Distillation Of Petroleum Products.
- 2.2-1 AR 40-5, Army Regulation, Medical Services, Preventive Medicine, 15 October 1990.
- 2.2-2 Environmental Protection Agency (EPA) Method 8260A, Volatile Organic Compounds By Gas Chromatography/Mass Spectrometry (GC/MS): Capillary Column Technique.
- 2.2-3 EPA Method 8000
- 2.3-1 MIL-PRF-87937C, Cleaning Compound, Aerospace Equipment.
- 2.3-2 ADS 61 Draft, paragraph 4.5.5, Performance Specification Cleaner, Aqueous And Solvent, For Army Aircraft.

## APPENDIX C. ABBREVIATIONS

AEC	= U.S. Army Environmental Center
ANSI	= American National Standards Institute
ASTM	= American Society for Testing and Materials
ATC	= U.S. Army Aberdeen Test Center
ATCOM	= U.S. Army Aviation and Troop Command
CCAA	= Commodity Command Approval Authorities
CFR	= Code of Federal Regulations
CHPPM	= U.S. Army Center for Health Promotion and Preventive Medicine
CLP	= cleaner, lubricant, preservative
DOD	= Department of Defense
EPA	= Environmental Protection Agency
FEJ	= failure-to-eject
FEX	= failure-to-extract
FFR	= failure-to-fire
FORSCOM	= U.S. Army Forces Command
GC/MS	= gas chromatography/mass spectrometer
HAP	= hazardous air pollutant
MEK	= methylethylketone
MSDS	= Material Safety Data Sheet
NSN	= national stock number
ODC	= ozone depleting chemical
PPE	= personnel protection equipment
RCRA	= Resource Conservation and Recovery Act
rms	= root mean square
SAE	= Society of Automotive Engineers
SEM	= scanning electron microscope
TACOM	= U.S. Army Tank-automotive and Armament Command
TECOM	= U.S. Army Test and Evaluation Command
TOP	= Test Operating Procedure
TTO	= total toxic organic
VOC	= volatile organic compound



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